EXPANDEO EDITION
The essential **reader** ¡n the history
of digital multimedia

multiMEDIA

FROM WAGNER TO VIRTUAL REALITY

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Foreword

Geeks and Artboys

By William Gibson

I can, these years latee, quite clearly see the shape of the chip I had on my shoulder when I wrote and/or assembled the piece that now stands as my contribution to the dis-course charted in this collection.

I was an artboy, or had become one in my own eyes, and I felt myself, in that era of unevenly emergent cyberstuff, and quite painfully, to be lumped ¡n with geeks of the first water.

I had not yet been given to recaí I that I had started out very much a geek myself, or seen that in so many ways I still was one. And I had been out,through much of the late eight-ies, on what Bruce Sterling dubbed the Virtual Chicken Circuit. Rather than the traditional rubber chicken, the alpha geeks of Virtual Reality and I had been dining on all sorts of delicacies (the bilí invariably picked up by some branch of the local bureaucracy charged with trying to figure out the shape of the future). We were ¡nvited to diñe in Tokyo, Barcelona, Venice, and Linz, because this was ¡n the heyday of the oíd gloves-and-goggles paradigm of VR, and there was a certain buzz to the effect that this stuff might be "the next televisión." At these events, I seem to recall, there was relatively little discussion of the Internet, or what its ¡ñipad: might be.The buzz was mainly around the goggies and the gloves, these end-user ¡nterface devices. As futurists, I'm afraid, we were scarcely worth the fancy dinners. As futurists so often do, we threw the baby out and brain-stormed the marvelous potential of the bath water.

The baby, an evolving and determinedly prehensile multimedia/ went right on evolving, and still does, no sign whatever of stopping, in a world made more than a littie unrecognizable by the passage of a mere fifteen years.

By the time I could be induced, by whatever sort of editorial suasion, to sit down and arrange words in a row about what I thought at some particular moment about all of this,1 had grown desperately tired of being mistaken for someone who knew what he was talking about.

Rather, I felt ¡t imperative that I noíknow what I was talking about. I wanted to be recognized for some subrational, basically shamanistic function that I was convinced I served. I wanted ¡t recognized that I was in fact an artboy. Which meant, at least ¡n my understanding of what it took to qualify, that I did not, must not, know what I was doing. If that which writes novéis, as someone once told me Henry James had said, is not that which attends dinner parties, I wanted it recognized that that which envisions "cyberspace" is not that which glazes over at the press conference following a federally funded VR fest.

Consequentiy I donned the attitudinal equivalent of a black raincoat, took the intertextual machete to a piece of my own fiction (originally commissioned by a Japanese cosmetics firm), and declared my literary descent from William S. Burroughs. I waxed nonlinear, burned brightly at both ends, and hoped to be definitively identified thereby as an artboy.

Had the volume you now hold existed then, I would probably have not been able to do that. Had I read this material, my eyes would have been opened in a very different way. I would have had to come to accept that Ted Nelson and William Burroughs, strange to think, were actually aiming, at various times, in the same direction.

I had had some inkling of this upon first discovering the cut-and-paste universe of word processing: I had seen that one could now do things, at least potentially, that Inspector Lee had scarcely dreamed of; henceforth all text was infinitely plástic, no scissors required. (Only recently have I had the opportunity to examine facsímile pages of Burroughs's cut-up "journals," which are astonishing prefigurations, in paper, of puré hypertext.)

I would have been presented with ampie evidence that geeks and artboys have considerable in common, under the skin, and *have* had, with regard to multimedia, from the very start. (The very start being entirely debatable, though I my-self have elsewhere described cave paintings as "the first screen.")

I had not read Douglas Engelbart or Vannevar Bush then, although I had read quite a lot of what is offered here on the artboy side. I did not then know, and I was struck by this repeatedly as I recently read or reread the texts collected.

"ere, that the rants of artboys tend to date quite early on, whereas the rants of geeks retain a certain timelessness and an enviable ¡ntensity.The reason for this, I think, is that artboys of whatever era are required to expend energy in the assumption of attitude, ¡n the donning of that black raincoat, whereas geeks (often quite scarily) are not.

I would have discovered Morton Heilig's Rube Goldberg, peculiarly *Popular Mechantes* visions of VR, neither geek ñor artboy but somehow Hollywood MasterTechie (and perhaps Hollywood was where the two impulses first fused, cinema having been the brilliant bastard offspring of a unión once unthinkable to anyone but a frothing Italian futurist).

I would have discovered, to my great delight, the figure of Billy Klüver, the perfect recombinant sport along the supposed great divide of the Two Cultures: a geek (Bell Laboratories láser systems engineer) whose inner artboy (collaborationswith Rauschenberg,Johns, and Warhol) allowed himto unhesitatingly and smilingly describe the great New York power failure of 1966 as "a Happening."

I would have seen a certain impulse toward nonlinearity, which I had been culturally conditioned to think of as the hallmark of the century's avant-garde, manifesting, often crucial ly, in the theorizing of Ivan Sutherland and Tim 8erners-L.ee.

I would, I hope, have been rightly humbled.

Who can read Vannevar Bush's "As We May Think" today and not be amazed by the weird acuity of this man's imagination? These visions of hyper-efficient, cigar-smoking technocrats, with walnut-sized "dry" cameras strapped to their foreheads, of glass-topped (and walnut-sided?) desks wherein are rear-projected images collected "in the field,"are, in their way, so genuinely, so embarrassingly, so rawly, prescient as to make a science fiction writer squirm. (There was a reason, you see, that Roosevelt was advised by Vannevar Bush, and not by Robert Heinlein or Isaac Asimov. Heinlein and Asimov were, relatively speaking, artboys. Bush, who personally put together what we think of today as the military industrial complex, was a *geek.)*

Today, in the opening years of a new century, I suspect that the distinction between the geek and the artboy means less than it ever has. Indeed, I wonder how effectively one can now be either to the exclusión of the other. And, indeed, I sometimes wonder how deep a distinction ¡t ever was. H ippies, someone must somewhere have pointed out, didn't discover LSD. And of al I those who partook ¡n that particular versión of the lotus, it now looks as though the ones who then shambled into the garage to continué fiddling with what eventual ly became the personal com-puter were the ones who most utterly and drastically and truly changed things.

My own early work is haunted by the collage constructions of Joseph Cornell, a prototypical artboy/geek (to the extent, it seems, of a sort of voluntary autism who fits nowhere at all ¡n the standard art histories, and by certain luxuriantly retrograde impulses in the work of Jorge Luis Borges, a poet who carne to regard his later role of librarían as inherently the more romantic of the two callings. Cornell treated the island of Manhattan as an ¡ntensely prívate archive of images, and was saíd to possess in photographic memory the exact contents of every secondhand shop in New York City, shelf by dusty shelf. Borges regarded the universe ¡tself as a library, infinitely recombinant, infinitely recursive, ¡n which a single text might exist ¡n variorum editions beyond number. I would add both these artists to the company collected here, and many more as well.

Multimedia, in my view, is not an invention but an ongoing discovery of how the mind and the universes it ¡magines (or vice versa, depending) fit together and ¡nteract. Multimedia is where we have always been going. Geeks and artboys, emerging together from the caves of Altamira, have long been about this great work.This book ¡s one start toward a different sort of history, a history cognizant of an impulse that seems to me always to have been with us.

I recommend this book to you with an earnestness that I have seldom felt for any collection of historie texts.This ¡s, ¡n large part, where the bodies (or, rather, the bones Of the ancestors) are buried. Assembled this way, in such provocativa proximity, these visions give off strange sparks.Think of it, if you like, as a cut-up in Burroughs's best sense, an ¡nterleaving of histories ¡ntended to open Íntertextual doors, some of whích, given the right reader, have never before been opened. Perhaps you are that reader.

If not, keep ¡t handy: you may be that reader one day, be you geek or artboy (of either gender, please) or (more likely) some evolved hybrid of the two.

Someone, it seems, always has to be.

—Vancouver, August 2000

overture

By Randall Packerand, Ken Jordán

kan Sutherland and Sketchpad. Courtesy of Lincoln Laboratory, MIT.

"And so the arts are encroachíng one upon another, and from a proper use ofthís encroachment wíll ríse the art that istruly monumental."

-WASSILY KANDINSKY

Multimedia is emerging as the defining médium of the twenty-first century. The World Wide Web, CD-ROMs, virtual reality arcade games, and Interactive ¡nstallations only hint at the forms of multimedia to come. Yet the concept of ¡ntegrated, ¡nteractive media has its own long history, an evolution that spans more than 150 years. Remarkably, this has been a largely untold story. Discussions of the develop-ment of the personal computer and the Internet tend to focus on *a* few highly successful entrepreneurs, neglecting the less-known work of the engineers and artists who first sought to craft a médium that would appeal to all the senses simultaneously—a médium that would mimic and enhance the creative capacities of the human mind. Mere, then, is a "secret history" of multimedia: a narrative that includes the pioneering activities of a diverse group of artists, scientists, poets, musicians, and theorists from Richard Wagner to Ivan Sutherland, from Vannevar Bush to Bill Viola.

Beginning with Wagner, subsequent generations of artists sought, and found, integrated forms and interdisciplinary strategies to express their concern with individual and social consciousness and extreme states of subjective experience. In the years since World War II, scientists have pursued personal computing and human-computer interactivity as vehicles for transforming consciousness, ex-tending memory, increasing knowledge, amplifying the intellect, and enhancing creativity.The idealistic and ideological aspirations of both groups have resulted in a new médium that emphasizes individual choice, free association, and personal expression.

Multimedia: From Wagner to Virtual Reality brings together the major writings by multimedia's pioneers for the first time in order to foster a greater understand-ing of its precedents, landmarks, aesthetic roots, social impact, and revolution-ary potential.

Douglos Engelbart. Gourtesy ofDouglas Engelbart, Bootstrap Institute.

Newtechnology has always been used to make media. George Lucas shot his latest *Star Wars* epic with digital cameras, though the audience experience was no ent than if it had been shot on celluloid. But while not all computer-based is multimedia, today's multimedia starts with the computer, and takes the st advantage of the computer's capability for personal expression. Digital computers were initially designed as calculating machines.The first *i* electronic computer, the EI\IIAC,was built by the United States military dur-World War II to produce ballistics tables for artillery ¡n battle. Computers **•en** were clumsy, hulking devices—the ENIAC had eighteen thousand vacuum Oes, and measured fifty feet by thirty feet—that did calculations for scientific esearch. Only a handful of scientists considered the possibility of personal com-rting for creative purposes by nonspecialists.

The first scientist to think seriously of this potential was Vannevar Bush. In s 1945 article "As We May Think," he outlined "a future device for individual jse, which is a sort of mechanized prívate file and library." Before the ENIAC was ::;mpleted, Bush was already contemplating how information technology could chance the individual'scapabiiity for creative thought. "The human mind ...operates by association," Bush observed. The device that he proposed, which he '-amed the memex, enabled the associative ¡ndexing of information, so that the -. ;der's trail of association would be saved inside the machine, available for reference at a later date. This prefigured the notion of the hyperlink. While Bush never actually built the memex, and while his description of it relied on technology that predated digital information storage, his ideas had a profound ¡nfluence on the evolution of the personal computer.

In the years immediately after the war, under the shadow of the atomic bomb, the scientific establishment made a concerted effort to apply recent advancements ¡n technology to humanitarian purposes. In this climate, Norbert Wiener completed his groundbreaking theory on cybernetics. While Wiener did not live to see the birth of the personal computer, his book, *The Human Use of Human Beings,* has become *derígueurior* anyone investigating the psychological and sociocultural implications of human-machine interaction. Wiener understood that the quality of our communication with machines affects the quality of our inner lives. His ap-proach provided the conceptual basis for human-computer interactivity and for our study of the social impact of electronic media.

Bush and Wiener established a foundation on which a number of computer scientists associated with the Advanced Research Projects Agency (ARPA)—a United States government-funded program to support defense-related research in the 1960s—began to build. Leading ARPA's effort to promote the use of computers in defense was the MIT psychologist and computer scientist J.C.R. Licklider, author of the influential article "Man-Computer Symbiosis." Defying the conventional wisdom that computers would eventually rival human intelligence rather than enhance it, Licklider proposed that the computer *be* developed as a creative collaborator, a tool that could extend human intellectual capabil-ity and improve a person's ability to work efficiently.

While at ARPA/ Licklider put significant resources toward the pursuit of his visión. Among the scientists he supported was Douglas Engelbart, who since the mid-1950s had been seeking support for the development of a digital informa-tion retrieval system inspired by Bush's memex. ARPA funding enabled Engelbart to assemble *a* team of computer scientists and psychologists at the Stanford Research Institute to créate a "tool kif'that would, as he phrased it, "augment human intellect." Dubbed theoNLine System (NLS), itspublic debut in 1968 at the Fall Joint Computer Conference in San Francisco was a landmark event in the history of computing. Engelbart unveiled the NLS before a room of three thousand computer scientists, who sat ¡n rapt attention for nearly two hours while he demonstrated some of his major innovations, including the mouse, win-dows for text editing, and electronic mail. Engelbart was making ¡t possible, for the first time, to reach virtually through a computer's ¡nterface to manipúlate ¡nformation. Each of his innovations was a key step toward an ¡nterface that al-lowed for intuitive interactivity by a nonspecialist. At the end of his presentation, he received a standing ovation.

However,thecontributionsof the NLS went beyond innovation regarding the computer ¡nterface. Engelbart and his colleagues also proposed that creativity could be enhanced by the sharing of ideas and Information through computers used as Communications devices. The oNLine System had its computers wired into a local network, which enabled them to be used for meaningful collabora-tion between co-workers. Engelbart understood that the

Personal computer would not only augment intelligence but augment communication as well. In 1969 his research in on-line networking
carne to fruition with the creation of ARPANET, the forerunner of the Internet.The first message on the ARPANET, in fact, was sent to Engelbart's lab at SRI from UCLA.

Engelbart's N LS pioneered some of the essential components necessary for the personal computer, but it would be up to a new generation of engineers to ad-vance computing so ¡t could embrace multimedia. As a gradúate student ¡n the late 1960s, Alan Kay wrote a highly influential Ph.D.thesis proposing a personal Information management device that, in many ways, prefigured the laptop. In 1970, as research ¡n Information science was shifting from East Coast universi-ties and military ¡nstitutions to prívate digital companies ¡n Silicon Valley, Kay was invited to join the new Xerox PARC (Palo Alto Research Center) in California. PARC's mándate was no less than to créate "the architecture of infor-mation for the future."

At PARC, Alan Kay pursued his ¡dea for the Dynabook—a notebook-sized puter that enabled hyperlinking, was fully ¡nteractive, and integrated all ia.Withthe Dynabook, digital multimedia carne into being. Echoing Licklider, BIbart, and colleagues at PARC, Kay declared the personal computer a ¡n its own right. It was a "meta-medium," as he described it ¡n his 1977 ′ "Personal Dynamic Media," capable of being "all other media." While the ᒥ- abook remained a prototype that was never built, the work that carne from • development, including the ¡nvention of the Graphical User Interface (GUI) : subsequent breakthroughs in dynamic computing, was incorporated into the : true multimedia computer, the Xerox Alto.

ie Integration ofthe Arts

Pepsi Pavilion. ***Photo by Harry Skunl Courtesy ofBilly Klüver, E.A. T.***

By proposing that the Dynabook be a "meta-medium" that unifies all media within a single interactive interface, Alan Kay had glimpsed into the future. But he may not have realized that his proposal had roots in the theories of the nineteenth-century Germán opera composer, Richard Wagner.

In 1849, Wagner ¡ntroduced the concept of the *Gesamtkunstwerk,* or Total Artwork, in an essay called "The Artwork of the Future." It would be difficult to overstate the power of this idea, or its influence. Wagner's description of the *Gesamtkunstwerk* is one of the first attempts in modern art to establish a practical, theoretical system for the comprehensive integration of the arts. Wagner sought the idealized unión of a//the arts through the "totalizing," or synthesizing, effect of music drama—the unification of music, song, dance, poetry, visual arts, and stagecraft. His drive to embrace the full range of human experience, and to reflect ¡t ¡n his operas, led him to give equal attention to every aspect of the final production. He was convinced that only through this ¡ntegration could he attain the expressive powers he desired to transform music drama into a vehicle capable of affecting Germán culture.

Twentieth-century artists have continued the effort to heighten the viewer's experience of art by ¡ntegrating traditional ly sepárate disciplines into single works. Modern experience, many of these artists believed, could be evoked only through an art that contained within itself the complete range of perception. "Old-fashioned"forms limited to words on a page, paint on a canvas, or music from an instrument were considered inadequate for capturing the speed, energy, and contradictions of contemporary ufe.

In their 1916 manifestó "The Futurist Cinema," F.T. Marinetti and his revolutionary cohorts declared film to be the supreme art because ¡t embraced all other art forms through the use of (then) new media technology. Only cinema, they claimed, had a "totalizing" effect on human consciousness. Less than a decade later, in his 1924 essay describing the theater of the Bauhaus, "Theater, Circus, Variety," László Moholy-Nagy called for a theater of abstraction that shifted the emphasis away from the actor and the written text, and brought to the fore every other aspect of the theatrical experience. Moholy-Nagy declared that only the synthesis of the theater's essential formal components—space, composition, motion, sound, movement, and light—into an organic whole could give expression to the full range of human experience.

The performance work of John Cage was a significant catalyst in the contin-uing breakdown of traditional boundaries between artistic disciplines after World War II. In the late 1940s, during a residency at Black Mountain College ¡n North Carolina, Cage organized a series of events that combined his interest in collaborative performance with his use of ¡ndeterminacy and chance operations in musical composition. Together with choreographer Merce Cunningham and

Robert Rauschenberg and Jasper Johns, Cage devised theatrical experi-that furthered the dissolution of borders between the arts. He was par-rly attracted to aesthetic methods that opened the door to greater :ipation of the audience, especial ly if these methods encouraged a height-I awareness of subjective experience. Cage's use of indeterminacy and chance-technique shifted responsibility for the outcome of the work away from ¡artist, and weakened yet another traditional boundary, the divide between art-
and audience.

I age's work proved to be extremely influential on the generation of artists : carne of age in the late 1950s. Alian Kaprow, Dick Higgins, and Nam June ¿k were among the most prominent of the artists who, inspired by Cage, de-ed nontraditional performance techniques that challenged accepted notions , categorization, and composition, leading to the emergence of genres such the Happening, electronic theater, performance art, and ¡nteractive ¡nstalla-

Kaprow, who coined the term "Happening," was particularly interested in bíurring the distinction between artwork and audience. The ultímate integrated *rt, he reasoned, would be without an audience, because every participant would se an integral part of the work. As he wrote ¡n his 1966 primer, "Untitled Guide-'esfor Happenings,""The une between art and lifeshould be kept as fluid, and rerhaps indistinct, *as* possible."This approach led to a performance style that p¡-:^eered delibérate, aesthetically conceived group interactivity in a composed en-. ronment. Happenings artists devised formal elements that allowed participants •_ne freedom to make personal choices and collective decisions that would affect ~*¿ie* performance.

In this climate, artists became increasingly interested in integrating technology into their work. While technology clearly played a significant role in twentieth-century arts (such as photography, film, and video, as well as various fine arts genres), it was not until Bell Labs scientist Billy Klüver placed the potential of advanced engineering into the hands of artists in New York that integrated worksof art and technology began to flourish. Klüver conceived the-notion of equal collaboration between artist and engineer. He pioneered forms of art and technology that would have been unimaginable to the artist without the engi-neer's cooperation and creative involvement.With Robert Rauschenberg, Klüver created several of the earliest artworks to intégrate electronic media and to en-courage a participatory role for the audience, including *Oracle* (1963-1965) and

In 1966 Klüver and Rauschenberg, along with Robert Whitman and Fred

Waldhauer, cofounded E.A.T. (Experiments in Art and Technology) to bring artists and engineers together to créate new works. E.A.T.'s most ambitious production was the Pepsi Pavilion, designed for the Osaka Expo '70 in Japan—a tremendously ambitious collaborative, multimedia project that ¡nvolved more than seventy-five artists and engineers. As Klüver explained, audience partícipation was at the heart of their interests: "The initial concern of the artists who designed the Pavilion was that the quality of the experience of the visitor should involve choice, responsibility, freedom, and participaron.The Pavilion would not tell astory or guide the visitor through a didactic, authoritarian experience.The visitor would be encouraged as an individual to explore the environment and compose his own experience."

During this period, the British artist and theorist Roy Ascott began to explore the use of computers in artistic expression. One of the first theoretical attempts to intégrate the emerging fields of human-computer interactivity and cybernetics with artistic practice was Ascott's article "Behavioral Art and the Cybernetic Vision," from 1966-1967. Ascott noted that the computer was "the supreme *tool* that... technology has produced. Used in conjunction with synthetic materials it can be expected to open up paths of radical change in art." Ascott saw that human-computer interaction would profoundly affect aesthetics, leading artists to embrace collaborative and interactive modes of experience.

When Alan Kay arrived at Xerox PARC in 1970, the foundation was ¡n place for a multimedia that synthesized al I the existing art forms, and presented them in an environment that allowed for meaningful interactivity. With the Dynabook, the interactive *Gesamkunstwerk* was brought into the digital realm, and put on-line.

Through the Looking Glass

The fantasy of being transported into another world, to be taken wholly ¡nto an imaginary realm, is a primal desire. With computer-based multimedia, encounterswith immersive, virtual worldswill soon become commonplace. Virtual reality, after all, ¡s a logical extensión of the integration of the arts. It is also an ideal environment for applying our knowledge of human-computer interactivity.

There is an evocative echo ¡n virtual environments of the earliest known form of human expression—the prehistoria cave paintings found at such sites as the caves of Lascaux in the south of France.These immersive environments, dating from 15,000 b.c., are thought by scholars to have been theaters for the performance of rituals that integrated all forms of media and engaged all the senses.

i the walls were painted animal ¡mages and shamanist scrawls, but the enviT>nment in which the paintings appeared was surely as significant as the paintthemseJves. As Joseph *Campbell descñbed ¡t, "these* mágica/ spots occur far i the natural entrantes of the grottos, deep within the dark, wandering chill •¡dors and vast chambers, so that before reaching them one has to experience the ful I forcé of the mystery of the cave itself." To encounter the cave paintings was to immerse the self in an otherworldly domain, which would heighten consciousness and trigger altered states of perception.

There are many examples of immersion ¡n the history of art. The Dyonisian rituals of Greek theater and the great cathedrals of Europe are two obvious examples. Richard Wagner's *Gesamtkunstwerk* was driven by a visión of theater in which the audience loses ¡tself in the veracity of the drama, creating an immersive experience. As he wrote in *The Artwork of the Future,* "the spectator transplants himself upon the stage, by means of all his visual and aural faculties."To facilítate his visión, Wagner reinvented the conventions of the opera house, and in 1876 opened the FestpielhausTheater in Bayreuth, Germany, with the first complete production of *The Ring* cycle.The Festpielhaus, with its employment of Greek amphitheatrical seating, surround-sound acoustics, the darkening of the house, and the placement of musicians in an orchestra pit, focused the audience's un-

SccttFúher. VIEW Head-Mounted Display. Courtesy of Scott Fisher, NASA-Ames Research Center.

divided attention on the dramatic action. His intent was to maximize the suspensión of disbel¡ef,to drawthe viewer into an illusionary world staged within the proscenium arch.

In the 1950s, a similar visión inspired the American cinematographer Morton Heilig to propose a "cinema of the future" that would surround the audience with facsímiles of life so convincing they would believe themselves to be transported to another domain. Such a cinema, he wrote, "would faithfully reproduce man's outer world as perceived in his consciousness, it will eventually learn to créate totally new sense materials for each of the senses . .. [that] they have never known before, and to arrange them into forms of consciousness never before experienced by man in his contact with the outer world."

While Heilig devised a theoretical framework that applied the technologies of his day toward the achievement of virtual experience, it was only as a consequence of advances in computer science that the ¡mmersion his work suggested became possible.

By 1965, Ivan Sutherland had already achieved legendary status among computer scientists as the inventor of Sketchpad, the first interactive graphics software. In a short paper published that year, Sutherland mused over the options available to the engineer to display computer data, to créate a "a looking glass" into what he described as a "mathematical wonderland." It seemed reasonable for him to suggest that "The Ultímate Display" (as the paper was titled) would represent this data in three-dimensional form, allowing the construction of entirely believable three-dimensional, computer-controlled, virtual worlds. However, like Heilig before him, Sutherland took this suggestion one step further."The ultímate display," he wrote, "would ... be a room within which the computer can control the existence of matter." He suggested that such a display could present realities heretofore only imagined, as ¡f seen through Aiice's looking glass. Sutherland's proposal was startling, but ¡t launched an entire field of scientific inquiry.

It also fueled the imagination of a generation of artists. One of the first to consider the possibilities of digitally constructed virtual experiences was Myron Krueger. In the early 1970s, Krueger created the pioneering works Meíap/ayand *Videoplaceto* explore the potential of computer-mediated interactivity.These works were ¡nteractive artistic environments, ¡nfluenced by Happenings, designed to give participants freedom of choice and opportunities for personal expression. *Video*p/acealso connected participants in different locations through networked technologies, creating the ¡llusión of shared space. As Krueger later wrote about the piece, "our teleconference created a place that consisted of the ¡nformation we *shared* ... a world in which full physical participation would be possible. ¡*orld is an 'artificial reality.' "

Notion that information might be treated as a "place" ¡nspired the re-i of N ¡cholas Negroponte and Richard A. Bolt at MIT's Architecture Ma-Group ¡n the late 1970s. Sutherland's proposal for a 3-D display implied a computer could represent information spatially. But how would such a *'.* actually work? To address this question, Negroponte and Bolt built the ary "media room/' drawing ideas from the heretofore divergent fields of dge management and architecture theory. As Bolt describes in his essay tial Data-Management/'their system involved "the creation of a plausible commodious 'virtual' space at the computer interface, together with a way g around in that space quickly and easily/'This virtual space, which *1* referred to as "Dataland," was projected onto the walls of the "media *n,"* surrounding the user, who navigated this data territory from a chair , pped with a joystick, touch screens, and a microphone, among other devices. During the 1980s, several engineering projects took the concept of virtual ironment display systems even further. Perhaps the most significant of these led by Scott Fisher at the N ASA-Ames Research Center. Fisher's intent was r gage the entire nervous system in a multisensory presentation of virtual ce—extending multimedia beyond the screen.The Ames VIEW system (an acronym for Virtual Interface Environmental Workstation) included a headset **•rth** two small liquid crystal display screens, a microphone for speech recog-•rtion, earphones for surround-sound effects, a head-tracking device, and a :a:aglove to recognize the user's gestures and place them within the virtual en-nronment. The direction this work pointed ¡n was clear. As Fisher wrote in his **1989** article "Virtual Interface Environments," "with full body tracking ca-pability, it would also be possible for users to be represented in this [virtual] space by life-size virtual representations of themselves ¡n whatever form they choose."

Immersive environments, Fisher observed, could give birth to a new form of participatory, Interactive electronic theater. Among the first to pursue such a theater was the artist Jeffrey Shaw, who began to incorpórate virtual reality into his installations in the míd-1980s. Shaw's installations are 3-D landscapes with a theatricality that entices the spectator to actively explore them. His work *The Legible City,* for example, presents an urban environment in which buildings are literal ly composed from words; the participant reads the texts by navigating through virtual city streets wearing a head-mounted display, riding a stationary bicycle that is, in fact, the work's interface.

By the late 1980s, the possibilities for this kind of Interactive, virtual theater had taken firm hold of the public's imagination. In *Neuromancer,* his widely read novel from 1984, William Gibson described in palpable detail a future in which virtual reality was a fact of life. Echoing Myron Krueger's notion that telecon-ferencing created a "place" that consisted of shared information, Gibson's char-acters inhabited a virtual environment made possible by the networking of computers, which he named "cyberspace." Gibson's cyberspace provided the first literary definition for the computers, hubs, servers, and databases that make up the matrices of the network. His discussion of cyberspace was so tangible—and seductive, with its suggestion that any computer hacker could "jack-in to the matrix" for an encounter with a sexy avatar—it became a touchstone for every engineer, artist, and theorist working in the field.

Marcus Novak took Gibson's description of virtual environments as the starting point for his own theoretical and artistic explorations. In his essay from 1991, "Liquid Architecture in Cyberspace," he follows the pioneering work of Sutherland, Fisher, and Gibson, et al., to its logical conclusion, and notes its profound implications for architecture, our notions of space, and our attitudes toward the organization of information. He notes that in cyberspace, since all structure is programmable, all environments can be fluid.The artist who designs these immersive digital habitats will be able to transcend the laws of the physical world. As a consequence, architectural forms built in cyberspace can respond to the viewer, encouraging provocative and illuminating interactions. In cyberspace, architecture becomes a form of poetry.

The artist Char Davies also investigates the mutable aspects of immersive environments, concentrating on the way the body responds to changes in the virtual space. For her immersive interactive multimedia work *Osmose* (1995), Davies augmented a head-mounted display and dataglove with sensors that allow the user to navigate imaginary worlds through breath and balance. The effect is to create a contemplative experience for the participant, which is triggered by the subtle, unconscious movements of the body.

While most research in virtual reality aims to project the viewer into a digital environment by means of a head-mounted display—as in the work of such media artists as Jaron Lanier, Brenda Laurel, and Jenny Holzer—someengineers have taken an alternative approach. In the early 1990s, Daniel Sandin and Thomas DeFanti conceived of a virtual reality system that places the human body directly inside a computer-generated environment. They describe their system, called the CAVE (an acronym for Cave Automatic Virtual Environment) in their article"Room with a View":"Unlike users of the video-arcadetype of virtual re-system, CAVE 'dwellers'do not need to wear helmets, which would limit their Jf and mobility ¡n the real world ... to experience virtual reality." Instead, its ¡n the CAVE are surrounded by an ¡mmersive, digital "cave paint--which brings the evolution of immersion ful I circle, back to the prehistoric)f Lascaux, and humankind's earliest efforts at personal expression.

Integrated Datawork

Imn *Hershman,* Lorna. © *Lynn Hershman. Courtesy ofLynn Hershman.*

It was Vannevar Bush who, in 1945, determined the chief narrative characteristic of multimedia by proposing a mechanical device that operated literally as we may think."The challenge, as he saw it, wasto créate a machine that supoorted the mind's process of free association. Bush noted how ¡deas tend to evolve in a nonlinear, idiosyncratic fashion. H is memex would be a tool that could supplement this aspect of human creativity by organizing its media elements to eflect the dynamics of the rnind at play.

Douglas Engelbart expanded on Bush's premise. His quest to "augment human ¡ntellect," as he aptly phrased it, was based on the insight that the open flow of ideas and information between collaborators was as ¡mportant to creativity as prívate free associatíon was.The personal computer, as he envisioned ¡t, would not only allow for the arrangement of data in idíosyncratic, nonlinear formats, but by connecting workstations to a data-sharing network and turning them into Communications devices, Engelbart's oNLine System allowed for a qualitative leap in the collaboration between individuáis—almost as if colleagues could peer into one another's minds as part of the creative process. In the early 1960s, experiments with networked personal computing promised the nonlinear organizaron of information on a grand scale.

While few recognized this possibility at the time, it ¡nspired a series of influential theoretical writings by the rogue philosopher Ted Nelson. Working outside the academic and commercial establishments, following his own strongly held convictions, Nelson devised an elabórate system for the sharing of information across computer networks. Called Xanadu, this system would maximize a computer's creative potential. Central to Nelson's approach was the "hyperlink," a term he coined ¡n 1963, inspired by Bush's notion of the memex's associative trails. Hyperlinks, he proposed, could connect discrete texts in nonlinear sequences. Usíng hyperlinks, Nelson realized, writers could créate "hypertexts," which he described as "nonsequential writing" that let the reader make decisions about how the text could be read ¡n other than linear fashion. As he observed in his landmark book from 1974, *Computer Lib/Dream Machines, "the structures of ideas are* notsequential/'With hypertext, and its multimedia counterpart, "hypermedia," writers and artists could créate works that encouraged the user to leap from one ¡dea to the next ¡n a series of provocative juxtapositions that presented alterna-tives to conventional hierarchies.

Nelson's ¡nsights were paralleled by experiments in the literary avant-garde that challenged traditional notions of linear narrative. In his book, he refers to Vladimir Nabokov's *Palé Fire ana* Julio Cortázar's *Hopscotchasiwo* novéis that use unconventional branching structures to encourage the reader's active collaboration in the construction of the story. As we have already seen, experimental performances inspired by John Cage—íncluding Happenings, interactive instal-lations, and performance art—also gave rise to a variety of nonlinear narrative strategies. But perhaps the most prescient explorer of this terrain was the nov-elist William S. Burroughs.

Like Ted Nelson, Burroughs was deeply suspicious of established hierarchies. He was especially ¡nterested in writing techniques that suggest the spontaneous, moment-by-moment movement of the mind, and how nonlinear writing might expand the reader's perception of reality.Through his use of the cut-up and fold-in techniques, which he described in his 1964 essay "The Future of the Novel," Burroughs treated the reading experience as one of entering into a multidirectional web of different voices, ideas, perceptions, and periods of time. He saw the cut-up as a tool that let the writer discover previously undetected connections bei things, with potentially enlightening and subversiva results. With the cut-Burroughs prefigured the essential narrative strategy of hypertext and its ′ to allow readers to leap across boundaries in time and space. unce the invention of the electric telegraph by Samuel Morse in the 1830s, entators have been noting the transformation of our concepts of space time by wired technology. From the telegraph to the telephone to televisión isatellite Communications, modern telecommunications has eradicated geo-lic borders, and made speed a central factor in modern life.This effect was anly acknowledged as long ago as 1868, when, at a banquet held in honor :-se's ufe achievement, he was toasted for having "annihilated both space Itime in the transmission of intelligence.The breadth of the Atlantic, with all

es, is as nothing."

Artists have grappled wíth the implications of this technology since its ¡n-on;the narrative experiments of literary authors reflect this current in mod-art. Ted Melson's concept of hypertext representad a profound effort to put •.rchnology toward the service of personal, idiosyncratic expression. Nelson ame an evangelist for hypertext, publishing articles, speaking at conferences, eading the gospel wherever he could. One of those places was Brown Univer-y, which during the 1980s became a hotbed of literary explorations of the i. At Brown, the literary critic George Landow and his colleagues developed ertexttools,such as Intermedia, which allowed authors with little experience programming to invent new genres of creative writing. In his own work, iow applied a trained critical eye to the formal aspects of hypertext, mak-rxj connections to the poststructural textual analysis of critics like Roland Barthes and Jacques Derrida. Just as academic theoretical discourse was ques-:oning the centrality of the author in the production of texts, hypermedia sug-gested that, in a future of networked digital media, responsibility would shift from author to reader, actively encouraging the reader's collaboration ¡n shaping a -arrative. Inventive hypertext fictions by authors such as Michael Joyce, Mark Amerika, Shelley Jackson, and Stuart Woulthrop explored the literary possibil-·ties of this nonlinear form of storytelling.

During this period, media artists whose roots lay ¡n performance and video also began investigating hypermedia as a means of exploring new forms for :ell¡ng stories. Artists such as Lynn Hershman and Bill Viola were drawn to the computer's ability to break down linear narrative structures. Viola approached the médium as a repository for evocative images that could be projected on screens ¡n installations, "with the viewer wandering through some three-dimensional, possibly life-sized field of prerecorded or simulated scenes evolving

¡n time/' as he described it. Hershman was among the first to créate digital artworks using Interactive media, ¡n such pieces as Deep *Contad,* from 1989. She introduced interactivity into her work to combat the loss of intimacy and control brought about by the dom'mance of media such as radio and televisión. Her use of hypermedia allowed the viewer to choose directions inside the artwork's complex branching structure, and shape a personal experience from it.

By the late 1980s, multimedia, which had been at the fringe of the arts and sciences, reached critical mass and went mainstream. Marc Canter, who developed the first commerdal multimedia authoring system, was a chief catalyst. Canter pioneered software tools that artists and designers used to créate multimedia on their personal computers. His authoring systems synthesized text, images, animation, video, and sound into a single ¡ntegrated work, using hyperlinks and other hypermedia techniques to connect its various elements.

In 1974,Ted Nelson had declared that "The real dream is for^everything'to be ¡n the hypertext." It was a proposal that echoed Marshall McLuhan's influential observation that "after more than a century of electric technology, we have extended our central nervous system itself ¡n a global embrace, abolishing both space and time as far as our planet is concerned." But despite Nelson's best efforts, and many advances in the fields of hypermedia and computer-based telecommunications,the global hypermedia library he envisioned remained more dream than reality. Most innovations ¡n hypermedia focused on closed systems, such as the CD-ROM and interactive installations, rather than on open systems using a computer network.

In 1989 Tim Berners-Lee, a young British engineer working at CERN, the particle physics laboratory in Geneva, Switzerland, circulated a proposal for ar in-house on-line document sharing system, which he described modestly as "a ᴺweb' of notes with links." After getting a grudging go-ahead from his superiors, Berners-Lee dubbed this system the World Wide Web. The Web, as he designec it, combined the Communications language of the Internet with Nelson's hyper text and hypermedia, enabling links between files to extend across a global net work. It became possible to link every document, sound file, or graphic on th» Web in an infinite variety of nonlinear paths through the network. And insteat of being created by a single author, links could be written by anyone participa! ing in the system. Not only did the open nature of the Web lend itself to a w¡d< array of interactive, multimedia experiences, but by hewing to a nonhierarchica structure and open protocols, Berners-Lee's invention became enormously pop ular, and led to an explosión ¡n the creation of multimedia. By 1993 the Web ha< truly become an international phenomenon.

; success of the Web seemed to confirm the intuition of artists engaging ¡n I media that in the future, a global media datábase would inspire new forms ssion. Roy Ascott, for example, had already been exploring the creative lilities of networking since the 1980s. He was interested in the notion of ace/'aterritory of information in which al I dataexists in acontinual pre-:- _tside the traditional definitions of time and space available for use in end-: .-xtapositions. Ascott considers dataspace a new type of *Gesamtkunstwerk,* or *atenwerk,* as he calis it, in which networked Information is ¡ntegrated into ¡artwork. In such an environment, Ascott writes, "meaning is not something by the artist, distributed through the network, and received by the ob-. Meaning is the product of interaction between the observer and the system, :ent of which is in a state of flux, of endless change and transformation." This notion of the artwork as a territory for interaction, as a locus of com-¡.:cations for a community, echoes the Happenings of a previous generation. artists Kit Galloway and Sherrie Rabinowitz were particularly intrigued by ¡ possibilities of extending collective experience through Communications tech-gies. Beginning ¡n 1975, they presided over a series of "teleperformances" used satellite hookups to link performers across great distances. In such arks as *Hole ¡n Space,* from 1980, they made the many-to-many spontaneous ommunication of a large number of participants the contení of their "teleper-:Tnance." Inspired by the technology's promise, the couple opened the Electric Cafe International in Santa Monica in 1989 as a research center and ¡rformance space to explore new forms of networked, collaborative art be-taeen artists and communities.

On-line role-playing games have also become laboratories for exploring this acsect of interactivity. As the social theorist Sherry Turkle has pointed out, on'"•e communities, such as Multi-User Dungeons (MUD), "are anewgenre of colaborative writing, with things ¡n common with performance art, street theater, -iprovisation theater, commedia dell'arte, and script writing." Pavel Curtís created one of the earliest MUDs, LambdaMOO, in 1990 at Xerox PARC.Though ít consisted only of text, its interactive quality, made possible through intricate storytelling devices via the Internet, gave participants the ¡llusión of immersion a virtual environment. Interaction in the on-line environment, Curtís claimed, creates a kind of social behavior which "in some ways ... is a direct mirror of behavior in real ufe."

Mirroring real life, computer-based interactivity has proven to be an invitation to inspire the viewer to shape his or her own experience of reality through electronic mediation.The theorist Janet Murray describes this as "agency," which she defines as "the satisfying power to take meaningful action and see the results of our decisions and choices." This form of agency has evolved in the network environment as a system for empowering the viewer to engage with the artist as a creative partner.

Throughout history, art has often been referred to as a mirror of life. But by building upon the twin notions of association and collaboration, computer-based multimedia may well become more than a mirror of life. Already we have seen how multimedia blurs the boundaries between life and art, the personal and the mediated, the real and the virtual. The implications of these tendencies we are only now beginning to grasp.

The Future Is Under Construction

Marcos Novak, Voice 3 + 4 Maze Blue. © *Marcos Novak. Courtesy of Marcos Novak.*The breadth and potential of multimedia lends itself to utopian proposals. The French media theorist Fierre Lévy describes multimedia as belonging to a tra-jectory of planetary evolution that runs from DNA to cyberspace—an are that follows pure information as it reaches toward its most evolved form of expres-sion. He proposes that today's global networks will usher in an era of "collective intelligence," and suggests that "cyberspace constitutes a vast, unlimited field ... designed to interconnect and provide interface for the various methods of cre-ation, recording, communication and simulation." His enthusiastic perspective evokes a world of intriguing possibilities.

! same time, we are al I aware of the dystopian qualities of the 24/7 in-: juggernaut that is being delivered across the globe through an ever | *phistícated telecommunications network. We read daily about the new ¡encroachment on privacy, its opportunity for abuse, and the specter of control that it might make possible.These dangers are real.There is i between opposing positions at the heart of the Internet—between those its potential for an open, freewheeling exchange of art and ideas and t«*K> see its pervasiveness as an opportunity to expand upon the marketing-broadcast model of twentieth-century media—and it is not at all clear [1] utopian or dystopian visions will ultimately prevail. **Ihe** articles in this book serve as a poignant reminder of the intentions of dia's pioneers.Their words, typically written during the heat of invention, a passionate involvement with higher ideáis. To a remarkable degree, ; scientists, artists, and theorists share a commitment to forms of media and jnications that are nonhierarchical, open, collaborative, and reflective of movement of the mind at play. It ¡s, in sum, an extraordinary visión. But er we will achieve it ¡s an unresolved question.

Toward *a* DeFinition of Multimedia

ne wake of postmodernist practice, computer-based media has resisted defini-—and for good reason: definitions are confining.They reduce the range of potrTi'al ¡n the object defined by drawing attention away from what lies outside the •a;l of definition.This is a particular concern with new media, because one of its =r.ractions is its fluid, multifarious character, its permeable walls. Digital media's peculiar nature challenges traditional categories; this ¡n itself is an aspect of its radical character. Butthere is valué ¡n proposing and discussing alternative definitions of digital media—even ¡f these definitions are contingent, bracketed by cir-istances. In fact, it may be best to regard them as contingent, because our í<perience with digital media is so fresh, and where it leads so unclear. The definitions of today will inevitably be replaced tomorrow, as new applications for digital media emerge over time.

Definitions are meant to establish a shared vocabulary that can focus argument—and often, covertly, to achieve a politically motivated purpose.The purpose of this book is overt: If, as Marshall McLuhan suggests, we literally construct the world we inhabit through the design and deployment of our media technologies—because they enable certain behaviors while discouraging others—then the social and political ramifications of how we define and address the emerging digital media are undeniable. By ¡dentifying *a* subject's key character-istics, we begin to say what it is and what it ¡s not. For digital media this is par-ticularly critical; if the digital arts community does not lead the discussion about how to define digital multimedia, and the types of behaviors it should or shouldn't encourage, other interests, like governments and corporations, will forcé a defi-nition on us.

The interests of for-profit entities often do not coincide with those of the creative community. In the case of digital, the multinational media corporations have made clear that their intent ¡s to maintain the legacy paradigms of twentieth-century media (which are hierarchical, broadcast-based, and author-centered) rather than support the emergence of challenging new media forms (which are, at their best, rhizomatic, peer-to-peer, and ¡nteractive). It ¡s in their interest to forcé compromises from the technology that will protect their traditional busi-nesses—compromises that effectively gut the most democratic, and creatively en-gaging, aspects of digital media. If it was up to these powerful companies, twenty-first-century media devices would likely do no more than act as delivery platforms for the media formats of the last century.

Today's situation ¡s much different from the way new media forms have emerged in the past. In the days of Gutenberg, the success of movable type did not depend on the coordinated acceptance of printing standards across medieval Europe. Rather, local innovations could emerge and take hold, and get adopted gradually. Regional ecosystems of media practice emerged over time; those that best suited the needs of society spread, establishing forms for personal expres-sion that improved through use.

The introduction of centralized, industrial forms of communication in the nineteenth century—like the telegraph, photography, telephones, audio recording, and cinema—required more global efforts at standardizaron. If a telegraph op-erator didn't know Morse code, then the telegraph became less valuable.The drive to make Morse code a universal standard went hand in glove with the expansión of the telegraph into increasingly remote regions. Still, significantly, each media standard of the day was unique to itself. Standards that emerged for photography paper had no influence on standards that were set for the telephone. Each médium grew independently, and so could find its way as a form of expression, before settling into a relatively rigid system with its own set of rules.

Digital multimedia is a departure from this established model, because it ¡n-corporates traditional ly ¡ndependent media forms into a single system. So the standards set for digital Communications will affect them all, simultaneously.

er, digital multimedia requires an unprecedented level of global coor-¡ wetl as a massive technical infrastructure and widespread user base. zs, the ¡nfrastructure is expensive. It demands standards agreed to by •nunity. Digital media calis for a far greater level of planning and de-Bource commitment than what we are familiar with from the past. **lis** reason, there is a need for a definition of digital media that brings **lio** rts most radical characteristics. If a televisión network trumpets the *click-to-buy TV shopping expresses digital media's greatest potential,
. ear way to say why that is not the case.
• "-as been written about narrow aspects of the digital media experience. swr, little critical work has been done to show how these sepárate aspects •ne into a whole.This book is an attempt to ¡dentify the core principies that, bound together, articúlate the ¡nherent capabilities in digital media that ! toward new forms of personal expression. Our intent is to draw a une be-ithe mainstream media forms of the past and a possible future. Though the implementations of digital media are still in development (and will con-! to be, relentlessly, given the f reedom to do so), we identif ied basic concepts : oersist, regardless of the technologies being used by an artist or engineer in i soecific situation. Could these concepts suggest a trajectory for future devel-|qpnent and provide a way to measure if digital media ¡s achieving what it ¡s ca-:of?

There are five characteristics of new media that, ¡n aggregate, define it as a •edium distinct from all others.These concepts set the scope of the form's ca-aaoilities for personal expression; they establish its ful I potential:

Integration: the combining of artistic forms and technology into a
hybrid form of expression. Interactivity: the ability of the user to manipúlate and affect her
experience of media directly, and to communicate with . others through media. Hypermedia: the linking of sepárate media elements to one another to
créate a trail of personal association. Immersion: the experience of entering into the simulation or
suggestion of a three-dimensional environment. *Narrativity: aesthetic and formal strategies that derive from the*

and medúa presentaron.
*

Together, these five concepts offer a definition of digital media that pushes toward the technical and aesthetic frontiers of the form.

Integration, of course, \s the foundation of multimedia; the combining of different media into a single work ¡s intrinsic to multimedia practice. While technology has always played a role in the development of forms of expression (since all media are technologies in their own right), beginning in the mid-twentieth century there was a delibérate effort to incorpórate technology as material, as a thing in itself, into artistic practice.This work, championed most visibly by Bell Labs engineer Billy Klüver, made technology an explicit aspect of the creation of art. This led, ¡n turn, to artists exploring the formal properties of electronic media and computers, ¡n order to make an art that is computer-specific. Because computer output can mimic traditional media, ¡t lends itself to artworks that blur the lines between media and between disciplines, just as in consciousness the distinctions between different media forms (image, text, sound, movement) are less than absolute.

Interactivity ¡s an overused word that is ¡n danger of losing ¡ts meaning. However, asoriginally conceived by Norbert Wiener, Douglas Engelbart,and others, interactivity has extraordinary promise.The term needs to be reclaimed from those who abuse it (by using it to describe home-shopping TV channels, for ¡nstance). By interactivity we specifically mean the ability of the user to alter media she comes in contact with, either alone or in collaboration with others. Reading a text is not an ¡nteractive experience; ¡nteractivity implies changing the words of the text ¡n some way—adding to them, reorganizing them, engaging with them in a way that affects their appearance on the screen. Digital media is inherently dynamic, changeable. Interactivity exploits this quality, and encourages a creative engagement by the user that leaves ¡ts mark on the artwork. Just as a conversation ¡s a two-way experience that affects both parties, interactivity ¡s an extensión of our instinct to communicate, and to shape our environment through communication.

Hypermedia may prove to be the most profound contribution that the computer has made to aesthetics. By making a persistent link between media objects, the user can now easily share her prívate path through them. Never before has it been so simple to make your own nonlinear method of navigating through ideas and information available to others. At the same time, using hypermedia, all traditional media forms tend to have the same weight. By writing links, you decide how to place emphasis on one media object ¡n relationship to another; context determines relative importance.Text leads to ímage leads to sound ¡n just the way the mind works.

But while hypermedia is potent in and of itself, without ¡nteractivity hyper-i would be limited to a way of browsing extant Ítems, rather than engaging 'with them. Interactívity is what empowers hypermedía, making it more **:the** experience of consciousness encountering the world. In life, one thought : to another, which leads you to your notebook, where you reread a line of tfien cross out one word and replace it with a different one. Without inter-:•« :>, hypermedia would place you in a state of continua! passivity, frustrating *f* impulse to engage with what you encounter.

Like hypermedia, ¡mmersion is a digitally enabled method for mimicking an of consciousness. The arts have long been concerned with accurately re-fccting prívate sensory perceptions. Tne history of each art form is replete with ements that claim this as their objective; similarly, integration has been led rthe desire to combine art forms in a way that reflects our sensual apprehen-of the world. Digital technology allows us to pursue this impulse even fur-through the creation of fully realized virtual environments. It is also true :~at, even when digital media does not suggest a convincing three-dimensional < '-.ual space, it encourages the use of spatial metaphors for the arrangement of —ormation. One obvious example is the Web, which lends itself to architectural ;' geographic methods of "navigation," rather than adhering to linear forms of o^ganization.

The interreliance between these key characteristics culminates in the wide range of nonlinear narrative forms that digital media lends itself to. Our methods for self-expression grow out of an ongoing collaboration with the tools we use to give that expression a recognizable shape. Working with these tools, we find ways to capture nuances of personal experience so that we can share them with others. Before digital technology, our tools led us toward linear modes of expression. However, the dynamic nature of databases and telecommunications networks open up possibilities for alternative narrative structures that come closer to replicating the internal associative tendencies of the mind. Artists like Lynn Hershman, Roy Ascott, and Bill Viola saw this potential early on and have explored approaches to narrativity that make full use of integration, interactivity, hypermedia, and ¡mmersion in their digital artworks.The narrative forms pioneered by these artists, and the many others who share their interests, are effectively blueprints for digital Communications to come in this century.

With the Dynabook in the early 1970s, Alan Kay invented a machine that incorporated al I five of these characteristics for the first time, giving birth to digital multimedia. However, much computer-based media today does not reflect tnese characteristics. *A Tale of Two Cities* screened on a personal digital assistant

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With the Dynabook in the early 1970s, Alan Kay invented a machine that in-corporated al I five of these characteristics for the first time, giving birth to digital multimedia. However, much computer-based media today does not reflect tnese characteristics. *A Tale of Two Cities* screened on a personal digital assistant remains a nineteenth-century novel; not everything digital ¡s multimedia. Yet with the addition of animated ¡ilustrations, hyperlinked text, an on-line discussion group, or, more ambitiously, a MUD-like role-playing game that takes place ¡n a virtual París at the time of the Revolution, Dickens's text might—for good or for ¡ll—become the basisfor a multimedia work. Justas movies have been based on novéis since the silent era, we are seeing multimedia adaptations of classic works, some of which may one day become classics themselves. Given the wide array of forms that multimedia currently takes—Internet art, virtual reality installations, graphical on-line chat spaces, and real-time networked performance, and many more to come —it might be fair to say that the medium's only defining element is its mutability, that we can't possibly predict the variety of its various mani-festations. Perhaps multimedia's most consistent quality will be ¡ts relentlessly changing nature.

In this book, one further attempt at definition has guided all the others: Multimedia is the form that makes the most complete use of the computer's potential for personal expression.

part *1*

Integration

Wagner

^{k}Outlines oFthe Artwork oF the Future," *The Artwork oftheFuture* (1849)

1

Richard Wagner.

"Whereas the publíc, that representaron ofdaily Ufe, forgets the confines ofthe auditorium, and Uves and breathes now on/y *in the artwork whích seems to ¡t as Ufe ¡tself, and on the stage which seems the wide expanse ofthe whole World."*

« For Richard Wagner, the "Artwork of the Future" represented a rejection of lyric opera, which the Germán composer considered hopelessly superficial, a tired showcase for pompous divas. Yet the ¡mplications of this landmark publi-cation go well beyond the transformation of opera. Wagner believed that the fu-ture of music, music theater, and al I the arts lay in an embrace of the ^{u}collective art-work," a fusión of the arts that had not been attempted on this scale since the classic Greeks. In this essay, we find the first comprehensive treatise argu-ing for the synthesis of the arts, or, as Wagner defines ¡t, the *Gesamtkunstwerk,* the total artwork.

Wagner was convinced that the sepárate branches of art—music, archi-tecture, painting, poetry, and dance—would attain new poetic heights when put to the service of the drama, which he viewed as the ideal médium for achiev-ing his visión. His totalizing approach to music theater also foreshadowed the experience of virtual reality. Scenic painting, lighting effects, and acoustical design were intended to render an entirely believable "virtual" world, ¡n which the proscenium arch serves as the interface to the stage environment. In 1876, twenty-seven years after *The Artwork of the Future,* Wagner took this approach even further when he opened the famous Festpielhaus Theater in Bayreuth, Germany, where his theatrical innovations ¡ncluded darkening the house, surround-sound reverberance, the orchestra pit, and the revitaliza-tion of the Greek amphitheatrical seating to focus audience attention onto the stage.

While Wagner's hyperromantic rhetoric may seem archaic today, there is acumen and foresight ¡n his approach to the *Gesamtkunstwerk* and the synthesis oí the arts, which illuminates contemporary notions of multimedia. »

. . . ArtIStIC Man can only fully contení himself by uniting every branch o Art into the *common* Artwork: in every *segregation* of his artistic faculties he is *u n free,* not fully that which he has power to be; whereas in the *common* Artwork hi *isfree,* and fully that which he has power to be.

The *true* endeavour of Art is therefore all-embracing: each unit who is inspired with a true *art-instinct* develops to the highest his own particular faculties, not for the glory of these special faculties, but for the glory *of genera Manhood in Art.*

The highest conjoint work of art is the *Drama:* it can only be at hand in a *xspossible* fulness, when in it each *sepárate branch ofart* is at hand in *its own utmut fulness.*

The truc Drama is only conceivable as proceeding from a *common urgence of* ***aten*** *art* towards the most direct appeal to a *common public.* In this Drama, each «párate art can only bare its utmost secret to their common public through a mu-mal parleying with the other arts; for the purpose of each sepárate branch ofart **can** only be fully attained by the reciprocal agreement and co-operation of all the fctanches in their common message.

Arthitecture can set before herself no higher task than to frame for a fellowship >f artists, who in their own persons portray the life of Man, the special sur-loundings necessary for the display of the Human Artwork. Only that edifice is built according to Necessity, which answers most beíittingly an aim of man: the highest aim of man is the artistic aim; the highest artistic aim—the Drama. In buildings reared for daily use, the builder has only to answer to the lowest aim of men: beauty is therein a luxury. In buildings reared for luxury, he has to sat-isfy an unnecessary and unnatural need: his fashioning therefore is capricious, unproductive, and unlovely. On the other hand, in the construction of that edifice whose every part shall answer to a common and artistic aim alone,—thus in ihe building of the *Theatre,* the master-builder needs only to comport himself as *artist,* to keep a single eye upon the *artwork.* In a perfect theatrical edifice, Art's nr£*á alone gives law ana* measure, down even to the smallest detail. This need 15 twofold, that *ofgiving* and that *ofreceiving,* which reciprocally pervade and condition one another. The *Scene* has firstly to comply with all the conditions of ~space" imposed by the joint *(gemeinsam)* dramatic action to be displayed thereon: but secondly, it has to íulfil those conditions in the sense of bringing this dramatic action to the eye and ear of the spectator in intelligible fashion. In the arrangement of the *spacefor the spectators,* the need for optic and acoustic un-derstanding of the artwork will give the necessary law, which can only be ob-ed by a unión of beauty and fitness in the proportions; for the demand of the collective *(gemeinsam)* audience is the demand for the *artwork,* to whose comprehension it must be distinctly led by everything that meets the eye.[1] Thus the ^>ectator transplants himself upon the stage, by means of all his visual and aural tculties; while the performer becomes an artist only by complete absorption into the public. Everything, that breathes and moves upon the stage, thus breathes and moves alone from eloquent desire to impart, to be seen and heard within those walls which, however circumscribed their space, seem to the actor from his scenic standpoint to embrace the whole of humankind; whereas the public, that representative of daily life, forgets the confines of the auditorium, and lives and breathes now only in the artwork which seems to it as Life itself, and on the stage which seems the wide expanse of the whole World

Here *Landscape-painting* enters, summoned by a common need which she alone can satisfy. What the painter's expert eye has seen in Nature, what he now, as artist, would fain display for the artistic pleasure of the full community, he dovetails into the united work of all the arts, as his own abundant share. Through him the scene takes on complete artistic truth: his drawing, his colour, his glowing breadths of light, compel Dame Nature to serve the highest claims of Art. That which the landscape-painter, in his struggle to impart what he had seen and fathomed, had erstwhile forced into the narrow frames of panel-pictures,—what he had hung up on the egoist's secluded chamber-walls, or had made away to the inconsequent, distracting medley of a picture-barn,—*therewith* will he henceforth ful the ample framework of the Tragic stage, calling the whole expanse of scene as witness to his power of re-creating Nature. The illusion which his brush and finest blend of colours could only hint at, could only distantly approach, he will here bring to its consummation by artistic practice of every known device of optics, by use of all the art of "lighting." The apparent roughness of his tools, the seeming grotesqueness of the method of so-called "scene-painting," will not offend him; for he will reflect that even the finest camel's-hair brush is but a humiliating instrument, when compared with the perfect Artwork; and the artist has no right to *pride* until he *is free, i.e.,* until his artwork is completed and alive, and *he,* with all his helping tools, has been absorbed into it. But the finished artwork that greets him from the *stage* will, set within this frame and held before the common gaze of full publicity, immeasurably more content him than did his earlier work, accomplished with more delicate tools. He will not, forsooth, repent the right to use this scenic space to the benefit of such an artwork, for sake of his earlier disposition of a flat-laid scrap of canvas! For as, at the very worst, his work re-mains the same no matter what the frame from which it looks, provided only it bring its subject to intelligible show: so will his artwork, in *this* framing, at any rate effect a livelier impression, a greater and more universal understanding, than the whilom landscape picture.

The organ for all understanding of Nature, is Man: the landscape-painter had not only to impart to men this understanding, but to make it for the first time plain to them by depicting Man in the midst of Nature. Now by setting his artwork in the frame of the Tragic stage, he will expand the individual man, to whom he would address himself, to the associate manhood of full publicity, and reap the satisfaction of having spread his understanding out to that, and made it partner in his joy. But he cannot fully bring about this public understanding until **he** allies his work to a joint and all-intelligible aim of loftiest Art; while this aim lüclf will be disclosed to the common understanding, past all mistaking, by the actual bodily man with all his warmth of life. Of all artistic things, the most directly understandable is the Dramatic-Action *(Handlung),* for reason that its art is not complete until every helping artifice be cast behind it, as it were, and gen-oine life attain the faithfullest and most intelligible show. And thus each branch of art can only address itself to the *understanding* iri proportion as its core— whose relation to Man, or derivation from him, alone can animate and justify the artwork—is ripening toward the *Drama.* In proportion as it passes over into Drama, as it pulses with the Drama's light, will each domain of Art grow all-intelligible, completely understood and justified.[2]

On to the stage, prepared by architect and painter, now steps *Artistic Man,* as Natural Man steps on the stage of Nature. What the statuary and the histórica! painter endeavoured to limn on *stone* or *canvas,* they now limn upon *them-iflves,* their form, their body's limbs, the features of their visage, and raise it to the consciousness of full artistic life. The same sense that led the sculptor in his grasp and rendering of the human figure, now leads the *Mime* in the handling and demeanour of his actual body. The same eye which taught the historical painter, in drawing and in colour, in arrangement of his drapery and composition of his groups, to find the beautiíul, the graceful and the characteristic, now orders the whole breadth *of actual human show.* Sculptor and painter once freed the Greek Tragedian from his cothurnus and his mask, upon and under which the real man could only move according to a certain religious convenüon. With justice, did this pair of plástic artists annihilate the last disfigurement of puré artistic man, and thus prefigure in their stone and canvas the tragic Actor of the Future. As they once descried him in his undistorted truth, they now shall let him pass into re-ality and bring his form, in a measure sketched by them, to bodily portrayal with all its wealth of movement.

Thus the illusion of plástic art will turn to truth in Drama: the plástic artist will reach out hands to the *dancer,* to the *mime,* will lose himself in them, and thus become himself both mime and dancer.—So far as lies within his power, he will have to impart the inner man his feeling and his will-ing, to the eye. The breadth and depth of scenic space belong to him for the plástic message of his stature and his motion, as a single unit or in unión with his fellows. But where his power ends, where the fulness of his will and feeling impels him to the *utteñng* of the inner man by means *ofSpeech,* there will the Word proclaim his plain and conscíous purpose: lie becomcs a *Poet* and, to be poet, a *tone-artist (Tonkünstler).*

But as dancer, tone-artist, and poet, he still is one and the same thing: nothing other than *executant, artistic Man, who, in thefullest measure ofhisfaculties, imparts himselfto the highest expression ofreceptive power.*

It is in him, the immediate executant, that the three sister-arts unite their forces in one collective operation, in which the highest faculty of each comes to its highest unfolding. By working in common, each one of them attains the power to be and do the very thing which, of her own and inmost essence, she longs to do and be. Hereby: that each, where her own power ends, can be absorbed within the other, whose power commences where her's ends,—she maintains her own purity and freedom, her independence as *that* which she is. The *mimetic dancer* is stripped of his impotence, so soon as he can sing and speak; the creations of *Tone* win all-explaining meaning through the mime, as well as through the poet's word, and that exacdy in degree as Tone itself is able to transcend into the mo-tion of the mime and the word of the poet; while the *Poet* first becomes a Man through his translation to the flesh and blood of the *Performer:* for though he metes to each artistic factor the guiding purpose which binds them all into a common whole, yet this purpose is first changed from "will" to "can" *by the poet's Will descending to the actor's Can.*

Not one rich faculty of the sepárate arts will remain unused in the United Artwork of the Future; in *it* will each attain its first complete appraisement. Thus, especially, will the manifold developments of Tone, so peculiar to our instrumental music, unfold their utmost wealth within this Artwork; nay, Tone will incite the mimetic art of Dance to entirely new discoveries, and no less swell the breath of Poetry to unimagined fill. For Music, in her solitude, has fashioned for herself an organ which is capable of the highest reaches of expression. This organ is the *Orchestra.* The tone-speech of Beethoven, introduced into Drama by the orchestra, marks an entirely fresh departure for the dramatic artwork. While Architecture and, more especially, scenic Landscape-painting have power to set the executant dramatic Artist in the surroundings of physical Nature, and to dower him from the exhaustless stores of natural phenomena with an ampie and significant background—so in the Orchestra, that pulsing body of many-coloured harmony, the personating individual Man is given, for his support, a stanchless elemental spring, at once artistic, natural, and human.

The Orchestra is, so to speak, the loam of endless, universal Feeling, from which the individual feeling of the sepárate actor draws power to shoot aloft to íullest height of growth: it, in a sense, dissolves[3] the hard immobile ground of the actual scene into a fluent, elastic, impressionable aether, whose unmeasured bottom is the great sea of Feeling itself. Thus the Orchestra is like the *Earth* from i Antaeus. so soon as ever his foot had grazed it, drew new immortal life-. By its essence diametrically opposed to the scenic landscape which sur-s the actor, and therefore, as to locality, most rightly placed in the deepened id outside the scenic frame, it at like time forms the perfect comple-tof these surroundings; inasmuch as it broadens out the exhaustless *physi*-F dcment of Nature to the equally exhaustless *emotional* element of artistic . These elements, thus knit together, endose the performer as with an at-f •oopheric ring of Art and Nature, in which, like to the heavenly bodies, he moves í in fullest orbit, and whence, withal, he is free to radiate on every side his ¡ and his views of Ufe—broadened to infinity, and showered, as it were, on ! **dbbnces** as measureless as those on which the stars of heaven cast their rays of

The place in which this wondrous process comes to pass, is the *Theatric r:* the collective art-work which it brings to light of day, the *Drama.* But to forre his own specific nature to the highest blossoming of its contents in this *one* and highest art-work, the sepárate artist, like each several art, must quell each self-sh. arbitrary bent toward untimely bushing into outgrowths unfurthersome to ¿»e whole; the better then to put forth all his strength for reaching of the highest common purpose, which cannot indeed be realised without the unit, ñor, on the other hand, without the unit's recurrent limitation.

This purpose of the Drama, is withal the only truc artistic purpose that ever can be fully *realised;* whatsoever lies aloof from that, must necessarily lose itself in the sea of things indefinite, obscure, unfree. This purpose, however, the sepárate art-branch will never reach *alone,*[4] but only *all together;* and therefore the most *universal* is at like time the only real, free, the only universally *intelligible* Art-work.

—translated by william ashton ellis

F.T. Marinelíi, Bruno Corra,
Emilio Settimelli, Arnaldo Ginna,
Giacomo Baila, Remo Lhiti

2 » "The Futurist Cinema" (1916)

10

F. T. Marinetti. ***Photo by Coletti.***

'We *shall set in motion the words-¡n-freedom that smash the boundaríes ofliterature as they march towards painting, muslc, noíse-art, and throw a marvelous brídge between the word and the real object."*

drama (always predictable), and killing the book (always tedious and oppressive). The necessities of propaganda will forcé us to publish a book once in a while. But we prefer to express ourselves through the cinema, through great ta-bles of words-in-freedom and mobile illuminated signs.

With our manifestó "The Futurist Synthetic Theatre," with the victorious tours of the theatre companies of Gualtiero Tumiati, Ettore Berti, Annibale Ninchi, Luigi Zoncada, with the two volumes *oí Futurist Synthetic Theatre* containing eighty theatrical syntheses, we have begun the revolution in the Italian prose theatre. An earlier Futurist manifestó had rehabilitated, glorified, and per-fected the Variety Theatre. It is logical therefore for us to carry our vivifying en-ergies into a new theatrical zone: the *cinema.*

At first look the cinema, born only a few years ago, may seem to be Futurist already, lacking a past and free from traditions. Actually, by appearing in the guise *oí theatre without words,* it has inherited all the most traditional sweepings of the literary theatre. Consequently, everything we have said and done about the stage applies to the cinema. Our action is legitímate and necessary in so far as the cinema up to now *has been and tenes to remain profoundly passéist,* whereas we see in it the possibility of an eminently Futurist art and *the expressive médium most adapted to the complex sensibility ofa Futurist artist.*

Except for interesting films of travel, hunting, wars, and so on, the film-makers have done no more than inflict on us the most backward-looking dramas, great and small. The same scenario whose brevity and variety may make it seem ad-vanced is, in most cases, nothing but the most trite and pious *analysis.* Therefore all the immense *artistic* possibilities of the cinema still rest entirely in the future.

The cinema is an autonomous art. The cinema must therefore never copy the stage. The cinema, being essentially visual, must above all fulfill the evolution of painting, detach itself from reality, from photography, from the graceful and solemn. It must become antigraceíul, deforming, impressionistic, Synthetic, dy-namic, free-wording.

one must free the cinema as an expressive médium in order to make it the ideal instrument *ofa new art,* immensely vaster and lighter than all the existing arts. We are convinced that only in this way can one reach *Úiatpolyexpressiveness* towards which all the most modern artistic researches are moving. Today the *Futurist cinema* créales precisely the polyexpressive symphony that just a year ago we announced in our manifestó "Weights, Measures, and Prices of Artistic Genius." The most varied elements will enter into the Futurist film as expressive means: from the slice of life to the streak of colour, from the conventional line to words-in-freedom, from chromatic and plástic music to the music of objects. In

: words it wül be painting, architecture, sculpture, words-in-freedom, music s. lines, and forms, a jumble of objects and reality thrown together at ran-. We shall offer new inspirations for the researches of painters, which will I to break out of the limits of the frame. We shall set in motion the words-in-i that smash the boundaries of literature as they march towards painting, :. noise-art, and throw a marvellous bridge between the word and the real

.- will be:

. C inematic **analogies** that use reality directly as one of the two elements of the analogy. Example: If we should want to express the anguished state of one of our protagonists, instead of describing it in its various phases of suffering, we would give an equivalent impression with the sight of ajagged and cavernous mountain.

The mountains, seas, woods, cities, crowds, armies, squadrons, aeroplanes, will often be our formidable expressive words: the universe will BE OUR vocabulary. Example: We want to give a sensation of strange cheerfulness: we show a chair cover flying comically around an enormous coat stand until they decide to join. We want to give the sensation of anger: we fracture the angry man into a whirlwind of little yellow balls. We want to give the anguish of a hero who has lost his faith and lapsed into a dead neutral scepticism: we *show* the hero in the act of matóng an inspÚTed speech to a great crowd; suddenly we bring on Giovanni Giolitti who treasonably stuffs a thick forkful of macaroni into the hero's mouth, drowning his winged words in tómalo sauce.

We shall add colour to the dialogue by swiftly, simultaneously show-ing eveiy image that passes through the actors' brains. Example: representing a man who will say to his woman: "You're as lovely as a gazelle," we shall show the gazelle. Example: if a character says, "I contémplate your fresh and luminous smile as a traveller after a long rough trip contémplales the sea from high on a mounlain," we shall show traveller, sea, mountain.

This is how we shall make our characters as understandable *as ifthey talked.*

2. **Cinematic poems, speeches, and poetry.** We shall make all of iheir componenl images pass across ihe screen.

Example: "Canto dell'amore" [Song of Love] by Giosué Carducci:

In their Germán strongholds perched Like falcons meditating the hunt

We shall show the strongholds, the falcons in ambush.

From the churches that raise long marble arms to heaven, in prayer to God
From the convenís between villages and towns
crouching darkly to the sound of bells
like cuckoos among far-spaced trees
singing boredoms and unexpected joys ...

We shall show churches that little by little are changed into imploring women, God beaming down from on high, the convenís, the cuckoos, and so on.

Example: "Sogno d'Estate" [Summer's Dream] by Giosué Carducci:

Among your ever-sounding strains of battle, Homer, I am conquered by the warm hour: I bow my head in sleep on Scamander's bank, but my heart flees to the Tyrrhenian Sea.

We shall show Carducci wandering amid the tumult of the Achaians, deftly avoiding the galloping horses, paying his respects to Homer, going for a drink with Ajax to the inn, The Red Scamander, and at the third glass of wine his heart, whose palpitations we ought to see, pops out of his jacket like a huge red balloon and flies over the Gulf of Rapallo. This is how we make films out of the most secret movements of genius.

Thus we shall ridicule the works of the passéist poets, transforming to the great benefit of the public the most nostalgically monotonous weepy poetry into violent, exciting, and highly exhilarating spectacles.

3. Cinematic simultanea y and intei pene tía t ion of diíferent times andplaces. We shall project two or three diñerent visual episodes at the sametime, one next to the other.
4. Cinematic musical researches (dissonances, harmonies, symphonies of gestures, events, colours, lines, etc.).
5. Dramatized states of mi nd on film.
6. Daily exercises in freeing ourselves from mere photographed logic.
7. Filmed dramas of objects. (Objects animated, humanized, baffled, dressedup, impassioned, civilized, dancing—objects removed from their normalsurroundings and put into an abnormal state that, by contrast, throws intorelief their amazing construction and nonhuman Ufe.)

8. **Show windows of filmed ideas, events, types, objects, etc.**

9. **Congresses, flirts, fíghts and marriages of funny faces, mimicry, etc.**

Example: a big nose that silences a thousand congressional fingers by ring-ing an ear, while two policemen's moustaches arrest a tooth.

10. **Filmed unreal reconstructions of the human body.**

10. **Filmed dramas of disproportion** (a thirsty man who pulís out a tiny drink-ing straw that lengthens umbilically as far as a lake and dries it up *instantly).*

10. **Potential dramas and strategic plans of filmed feelings.**

10. **Linear, plástic, chromatic equivalences, etc.,** of men, women, events,thoughts, music, feelings, weights, smells, noises (with white Unes on blackwe shall show the inner, physical rhythm of a husband who discovers hiswife in adultery and chases the lover—rhythm of soul and rhythm oflegs).

11. **Filmed words-in-freedom in movement** (synoptic tables oflyric valúes—dramas of humanized or animated letters—orthographic dramas—typo-graphical dramas—geometric dramas—numeric sensibility, etc.).

Painting + sculpture + plástic dynamism + words-in-freedom + com-posed noises *[intonarumorí]* + architecture + synthetic theatre = Futurist cinema.

THIS IS HOW WE DECOMPOSE AND RECOMPUSE THE UNIVERSE ACCORDING TO OUR MARVELLOUS WHIMS, to centuple the powers of the Italian creative genius and its absolute pre-eminence in the world.

11 SEPTEMBER1916

—translated by R. W. flint

3 » "Theater, Circus, Variety"

"Theater, Circus, Variety," *TheateroFthe Bauhaus* 17

« Founded ¡n Weimar, Germany, ¡n 1919, the Bauhaus School is best known *or its contribution to industrial design. But artists such as László Moholy-*Jagy, Oskar Schlemmer, Paul Klee, and Wassily Kandinsky undertook a wide range of aesthetic investigations, using the school as a laboratory to examine the -ormal principies of abstraction ¡n painting, photography, and sculpture. They *z* so explored the ¡nfluence of technology, which had a profound ¡mpact on their Aork and ideas.These experiments led Moholy-Nagy and Schlemmer to develop a new kind of theater based on these principies. Their work was an attempt to synthesize the theater's essential components—space, composition, motion, sound, movement, and light—into a fully integrated, abstract form of artistic expression.

Moholy-Nagy referred to this ¡dea as the Theater of Totality, a reinterpreta-: on of Wagner's concept of "total theater." Moholy-Nagy's approach to the syn-:ʳesis of the arts reduced the importance of the written word and the presence :; the actor, placing them on an equal plateau with stage design, lighting, music, and visual composition. His concept of the "Mechanized Eccentric" ¡njected the qualities of machinery into every aspect of the stage performance, ¡ncluding the costume design, props, and movement of the actors, resulting in a theater that e-nphasized the physical rather than the literary, and that reflected the speed, dy-namism, and precisión of state-of-the-art technology. It ¡s notable that Moholy-Nagy integrated mechanical motifs in all his work—not only theater but also *cainting, photography, film, and* scuJpíure.

In addition, Moholy-Nagy's theater challenged the relationship between the spectator and the performance. He called for the use of techniques that would alter the theatrical space, removing the traditional "fourth wall" that separated tne audience from the stage. He envisioned mechanical devices that would move across a multiplaned stage, a reorganizaron of the space that would literally im-nerse spectators ¡n the action. As Moholy-Nagy put it, the Bauhaus Theater would challenge the passivity of the audience, and "actually allow them to fuse with the action on the stage at the peak of cathartic ecstasy." »

1. the historical theater

The historical theater was essentially a disseminator of information or propaganda, or it was an articulated concentrador! of action *(Aktionskonzentration)* de-rived from events and doctrines in their broadest meaning—that is to say, as "dramatized" legend, as religious (cultist) or political (proselytizing) propaganda, or as compressed action with a more or less transparent purpose be-hind it.

The theater diñered from the eyewitness report, simple storytelling, didactic moralizing, or advertising copy through its own particular synthesis of the elements of presentation: souND, color (light), motion, space, form (objects AND PERSONS).

With these elements, in their accentuated but often uncontrolled interrelationships, the theater attempted to transmit an articulated experience.

In early epic drama *(Erzahlungsdrama)* these elements were generally employed as illustration, subordinated to narration or propaganda. The next step in this evolution led to the drama of action *(Aktionsdrama),* where the elements of dynamic-dramatic movement began to crystallize: the theater of improvisaron, the *commedia delirarte.* These dramatic forms were progressively liberated from a central theme of logical, intellectual-emotional action which was no longer dominant. Gradually their moralizing and their tendentiousness disappeared in favor of an unhampered concentration on action: Shakespeare, the opera.

With August Stramm, drama developed away from verbal context, from propaganda, and from character delineation, and toward explosive activism. Creative experiments with motion and sound (speech) were made, based on the Ímpetus of human sources of energy, that is, the "passions." Stramm's theater did not offer narrative material, but action and tempo, which, unpremeditated, sprang al-most automatically and in headlong succession from the human impulse for motion. But even in Stramm's case action was not altogether free from literary en-cumb ranee.

"Literary encumbranee" is the result of the unjustifiable transfer of intellectualized material from the proper realm of literary eífectiveness (novel, short story, etc.) to the stage, where it incorrectly remains a dramatic end in itself. The result is nothing more than literature if a reality or a potencial reality, no matter how imaginativo, is formulated or visually expressed without the creative forms peculiar only to the stage. It is not until the tensions concealed in the utmost economy of means are brought into universal and dynamic interaction that we have creative stagecraft *(Bühnengestaltung).*

Even in recent times we have been deluded about the true valué of creative stagecraft when revolutionary, social, eth-ical, or similar problems were unrolled with a great display of literary pomp and paraphernalia.

"Theater, Lircus, Variety," *Theater ofthe Bauhaus* 19

2. attempts at a theater form for today

a) Theater ofSurprises: Futurists, Dadaists, Merz

In the investigation of any morphology, we proceed today from the all-inclusive functionalism of goal, purpose, and materials.

From this premisa the futurists, expressionists, and dadaists (merz) carne to the conclusión that phonetic word relationships were more significan! than other creative literary means, and that the logical-intellectual contení *(das Logisch-Gedankliche)* of a work of literature was far from its primary aim. It was maintained that, just as in representational painting it was not the contení as such, not the objects represented which were essential, but the interaction of colors, so in literature it was not the logical-intellectual content which belonged in the foreground, but the effects which aróse from the word-sound relationships. In the case of some writers this idea has been extended (or possibly con-tracted) to the point where word relationships are transformed into exclusively phonetic sound relationships, thereby totally fragmenting the word into conceptually disjointed vowels and consonants.

theater which aimed at the elimination of logical-intellectual (literary) aspects. Yet in spite of this, man, who until then had been the solé representative of logical, causal action and of vital mental activities, still dominated.

b) The Mechanized Eccentric (Die mechanische Exzentrik)

As a logical consequence of this there aróse the need for a MECHANIZED eccentric, a concentration of stage action in its purest form *(eme Aktionskonzentration derBühne in Reinkultur).* Man, who no longer should be permitted to represent himself as a phenomenon of spirit and mind through his intellectual and spiritual capacities, no longer has any place in this concentration of action. For, no mat-ter how cultured he may be, his organism permits him at best only a certain range of action, dependent entirely on his natural body mechanism.

The effect of this body mechanism *(Korpermechanik)* (in circus performance and athletic events, for example) arises essentially from the spectator's astonish-ment or shock at the potentialities of his *own* organism as demonstrated to him by others. This is a subjective efíect. Here the human body is the solé médium of configuration *(Gestaltung).* For the purposes of an objective *Gestaltung* of movement this médium is limited, the more so since it has constant reference to sensible and perceptive (i.e., again literary) elements. The inadequacy of "human" *Exzentrik* led to the demand for a precise and fully controlled organi-zation of form and motion, intended to be a synthesis of dynamically contrasting phenomena (space, form, motion, sound, and light). This is the Mechanized Ec-centric.

I

3. the coming theater: theater of totality

Every form process or *Gestaltung* has its general as well as its particular premises. from which it must proceed in making use of its specific media. We might, there-fore, clarify theater production *(Theatergestaltung)* if we investigated the nature of its highly controversial media: the human *word* and the human action, and. at the same time, considered the endless possibilities open to their creator—man.

The origins of music as conscious composition can be traced back to the melodic recitations of the heroic saga. When music was systematized, permitting only the use of HARMONiES (klange) and excluding so-called sounds (gerausche). the only place left for a special sound form *(Gerauschgestaltung)* was in literatura, particularly in poetry. This was the underlying idea from which the Expression-ists, Futurists, and Dadaists proceeded in composing their sound-poem-*(Lautgedichte).* But today, when music has been broadened to admit sounds o: all kinds, the sensory-mechanistic effect of sound interrelationships is no longer a monopoly of poetry. It belongs, as much as do harmonies *(Tone),* to the realm of music, much in the same way that the task of painting, seen as color creation. is to organize clearly primary (apperceptive) color eífect. Thus the error of the Futurists, the Expressionists, the Dadaists, and all those who built on such foun-dations becomes clear. As an example: the idea of an *Exzentrik* which is only mechanical.

It must be said, however, that those ideas, in contradistinction to a literary-illustrative viewpoint, have unquestionably advanced creative theater precisely because they were diametrically opposed. They canceled out the predominance of the exclusively logical-intellectual valúes. But once the predominance has been broken, the associative processes and the language of man, and consequently man himself in his totality as a formative médium for the stage, may not be barred from it. To be sure, he is no longer to be pivotal—as he is in traditional theater— but is to be employed on an equal footing with the other formative media.

Man as the most active pnenomenon of life is indisputably one of the most ef-fective elements of a dynamic stage production *(Bühnengestaltung),* and there-fore he justifies on functional grounds the utilization of his totality of action, speech, and thought. With his intellect, his dialectic, his adaptability to any sit-uation by virtue of his control over his physical and mental powers, he is—when used in any concentration of action *(Aktionskonzentration)*—destined to be pri-marily a configuraron of these powers.

And if the stage didn't provide him full play for these potentialities, it would be imperative to créate an adequate vehicle.

But this utilization of man must be clearly diíferentiated from his appearance heretofore in traditional theater. While there he was only the interpreter of a lit-erarily conceived individual or type, in the new theater of totality he will use the spiritual and physical means at his disposal PRODUCTiVELY and from his own INITIATIVE submit to the over-all action process.

While during the Middle Ages (and even today) the center of gravity in theater production lay in the representation of the various *types* (hero, harlequin, peasant, etc.), it is the task of the FUTURE actor to discover and actívate that which is common to all men.

In the plan of such a theater the traditionally "meaningful" and causal intercon-nections can not play the major role. In the consideration of stage setting as an *artform,* we must learn from the creativa artist thatjust as it is impossible to ask what a man (as organism) is or stands for, it is inadmissible to ask the same ques-tion of a contemporary nonobjective picture which likewise is a *Gestaltung,* that is, an organism.

The contemporary painting exhibits a multiplicity of color and surface interrelationships, which gain their effect, on the one hand, from their conscious and logical statement of problems, and on the other, from the unanalyzable intangibles of creative intuition.

In the same way, the Theater of Totality with its multifarious complexities c: light, space, plañe, form, motion, sound, man—and with all the possibilities fi i varying and combining these elements—must be an ORGANISM.

Thus the process of integrating man into creative stage production must be un-hampered by moralistic tendentiousness or by problems of science or the INDIVIDUAL. Man may be active only as the bearer of those functional elements which are organically in accordance with his specific nature.
It is self-evident, however, that all *other* means of stage production must be given positions of effectiveness equal to man's, who as a living psychophysical or-ganism, as the producer of incomparable climaxes and infinite variations, de-mands of the conformative factors a high standard of quality.

4. How shall the theater of totality be realized?

One of two points of view still important today holds that theater is the concentrated activation *(Aktionskonzentration)* of sound, light (color), space, form, and motion. Here man as coactor is not necessary, since in our day equipment can be constracted which is far more capable of executing the *purdy mech&nical* role of man than man himself.
The other, more popular view will not relinquish the magnificent instrument which is man, even though no one has yet solved the problem of how to employ him as a creative médium on the stage.
Is it possible to include his human, logical functions in a present-day concentration of action on the stage, without running the risk of producing a copy from nature and without falling prey to Dadaist or Merz characterization, com-posed of an eclectic patchwork whose seeming order is purely arbitrary?
The creative arts have discovered puré media for their constructions: the primary relationships of color, mass, material, etc. But how can we intégrate a se-quence of human movements and thoughts on an equal footing with the con-trolled, "absolute" elements of sound, light (color), form, and motion? In this regard only summary suggestions can be made to the creator of the new theater *(Theatergestalter).* For example, the repetition of a thought by many actors, with identical words and with identical or varying intonation and cadenee, could be employed as a means of creating synthetic (i.e., unifying) creative theater.

(This would be the CHORUS—but not the attendant and passive chorus of antiq-uity!) Or mirrors and óptica! equipment could be used to project the gigantically enlarged faces and gestures of the actors, while their voices could be amplified to correspond with the visual MAGNIFICATION. Similar effects can be obtained from the simultaneous, SYNOPTICAL, and synacoustical reproductíon of thought (with motion pictures, phonographs, loud-speakers), or from the reproduction of thoughts suggested by a constructipn of variously meshing gears *(eine* zah-nradartig INEINANDERGREIFENDE *Gedankengestaltung)'.*

Independen! of work in music and acoustics, the literature of the future will créate its own "harmonies," at first primarily adapted to its own media, but with íar-reaching implications for others. These will surely exercise an influence on the word and thought constructions of the stage.

This means, among other things, that the phenomena of the subconscious and dreams of fantasy and reality, which up to now were central to the so called "intímate art theater" ("kammerspiele"), may no longer be predominant. And even if the conflicts arising from today's complicated social patterns, from the world-wide organization of technology, from paciíist-utopian and other kinds of revolutionary movements, can have a place in the art of the stage, they will be sig-nificant only in a transitional period, since their treatment belongs properly to the realms of literature, politics, and philosophy.

We envision total stage action (gesamtbühnenaktion) as a great dynamic-rhythmic process, which can compress the greatest clashing masses or accumu-lations of media—as qualitative and quantitative tensions—into elemental form. Part of this would be the use of simultaneously interpenetrating sets of contrast-ing relationships, which are of minor importance in themselves, such as: the tragicomic, the grotesque-serious, the trivial-monumental; hydraulic spectacles; acoustical and other "pranks"; and so on. Today's circus, operetta, vaude-ville, the clowns in America and elsewhere (Chaplin, Fratellini) have accom-plished great things, both in this respect and in eliminating the subjective—even if the process has been naive and often more superficial than incisive. Yet it would be just as superficial if we were to dismiss great performances and "shows" in this genre with the word *Kitsch.* It is high time to state once and for all that the much disdained masses, despite their "academic backwardness," often exhibit the soundest instincts and preferences. Our task will always remain the creative un-derstanding of the true, and not the imagined, needs.

5. the means

Every *Gestaltung* or creative work should be an unexpected and new organism, and it is natural and incumben! on us to draw the material for surprise ef-fects from our daily living. Nothing is more effective than the exciting new possibilities ofFered by the familiar and yet not properly evaluated elements ot modern life—that is, its idiosyncracies: individuation, classification, mechanization. With this in mind, it is possible to arrive at a proper understanding oí stagecraft through an investigation of creative media other than man-as-actor himself.

In the future, SOUND EFFECTS will make use of various acoustical equipmen: driven electrically or by some other mechanical means. Sound waves issuing from unexpected sources—for example, a speaking or singing are lamp, loud-speakers under the seats or beneath the floor of the auditorium, the use of new amplifying systems—will raise the audience's acoustic surprise-threshold so much that unequal effects in other áreas will be disappointing.

color (light) must undergo even greater transformation in this respect than sound.

Developments in painting during the past decades have created the orgaru-zation of absolute color valúes and, as a consequence, the supremacy of puré and luminous chromatic tones. Naturally the monumentality and the lucid balance their harmonies will not tolérate the actor with indistinct or splotchy make-up and tattered costuming, a product of misunderstood Cubism, Futurism, etc. The use of precision-made metallic masks and costumes and those of various other composition materials will thus become a matter of course. The pallid face, t:.: subjectivity of expression, and the gestures of the actor in a colored stage envi-ronment are therefore eliminated without impairing the effective contrast be-tween the human body and any mechanical construction. Films can also be projected onto various surfaces and further experiments in space illuminati will be devised. This will constitute the new action of light, which by mean» of modern technology will use the most intensified contrasts to guarantee it^r a position of importance equal to that of all other theater media. We have not y; begun to realize the potential of light for sudden or blinding illumination, for *&¿J*-effects, for phosphorescent effects, for bathing the auditorium in light synchro-ni/ed with climaxes or with the total extinguishing of lights on the stage. All this.

of course, is thought of in a sense totally difieren! from anything in current tradirional theater.

From the time that stage objects became mechanically movable, the generally traditional, horizontally structured organization of movement in space has been enriched by the possibility of vertical motion. Nothing stands in the way of mak-ing use of complex APPARATUS such as film, automobile, elevator, airplane, and odier machinery, as well as optical instruments, reflecting equipment, and so on. The current demand for dynamic construction will be satisfied in this way, even though it is still only in its first stages.

There would be a further enrichment if the present isolation of the stage could be eliminated. In today's theater, stage and spectator are too much separated, too obviously divided into active and passive, to be able to produce creative re-lationships and reciproca! tensions.

It is time to produce a kind of stage activity which will no longer permit the masses to be silent spectators, which will not only excite them inwardly but will let them *take hold and partícipate*—actually allow them to fuse with the action on the stage at the peak of cathartic ecstasy.

To see that such a process is not chaotic, but that it develops with control and organization, will be one of the tasks of the thousand-eyed new director, equipped with all the modern means of understanding and communication.

It is clear that the present peep-show stage is not suitable for such organized motion.

The next form of the advancing theater—in cooperation with íuture authors—will probably answer the above demands with suspended bridges and drawbridges running horizontally, diagonally, and vertically within the space of the theater; with platform stages built far into the auditorium; and so on. Apart from rotating sections, the stage will have movable space constructions and dislike áreas, in order to bring certain action moments on the stage into prominence, as in film "close-ups." In place of today's periphery of orchestra loges, a runway joined to the stage could be built to establish—by means of a more or less caliper-like embrace—a closer connection with the audience.

The possibilities for a variation of levels of movable planes on the stage of the future would contribute to a genuine organization of space. Space will then no longer consist of the interconnections of planes in the oíd meaning, which was able to conceive of architectonic delineation of space only as an en-closure formed by opaque surfaces, The new space originales from free-standing surfaces or from linear definition of planes (wire frames, antennas), so that the surfaces stand at times in a very free relationship to one another, without the need of any direct contad.

As soon as an intense and penetrating concentration of action can be functionally realized, there will develop simultaneously the corresponding auditorium ARchitecture. There will also appear costumes designed to emphasize function and costumes which are conceived only for single moments of action and capa-ble of sudden transformations.

There will arise an enhanced *control* over all formative media, unified in a harmonious eífect and built into an organism of perfect equilibrium.

—translated by arthur S. wensinger

Dick Higgins

"Intermedia" (1966)

4

Dick Higgins (secondfrom left) performing Philip Corner's "Piano Activities." Courtesy ofArchiv Sohm, Staatsgalerie Stuttgart.

"The Happen'mg developed as ¡ntermedium, an uncharted land that líes between collage, muslo, and the theater. It ¡s not governed by rules; each work determines ¡ts own médium and form according to its needs."

« Fluxus artist Dick HIggins describes a branch of American postmodernism from the 1960s that reflects the tumultuous social atmosphere of the era and ¡ts impact on the arts. Higgins's attention is focused on intermedia, a myriad of emerging genres that spilled across the boundaries of traditional media. In the interstices between the arts, mixed-media forms coalesced: Happenings, performance art, kinetic sculpture, electronic theater, as well as a variety of deliberately uncategorizable works.

Higgins cites Marcel Duchamp's readymades, ¡ncluding the ¡nfamous urinal *Fountaín,* asthefirst challenge to the European tradition of the sacred aura of the artwork. Following the example of Duchamp, Higgins suggests that artists explore the territory that lies between "the general área of art media and those of life media." He callsfor unusual combinations of art, ¡ncluding, for instance, the mixing of painting and shoes (as ¡n the art of Claes Oldenberg). With intermedia, any available object or experience can be incorporated into the artwork. This was the notion at the core of the Happening, a form of performance pio-neered by Oldenberg, Alian Kaprow, Jim Diñe, and Robert Whitman that was the pinnacle of intermedia art. Their works took place in staged environments, presented as collages of action, music, and found objects that the audience encountered ¡n an order typically without linear development, and without the through line of traditional narrative.

The art of "mixed-means" was defined by ¡ts tendency to establish an open system without rules or boundaries.This open-endedness allowed Higgins and his colleagues to extend the Happening to incorpórate the audience as an additional, composed element of the work; as he put it: "uve people as part of the collage." This shift ¡n the role of the spectator had profound ¡mplications for the evolution of interactive media art, and its ¡nfluence is felt in the changing role of the viewer in human-computer interaction. »

IVLIIch. of the best work being produced today seems to fall between media. This is no accident. The concept of the separation between media aróse in the Renaissance. The idea that a painting is made of paint on canvas or that a sculpture should not be painted seems characteristic of the kind of social thought—cat-egorizing and dividing society into nobility with its various subdivisión», untitled gentry, artisans, serfs and landless workers—which we cali the feudal conception of the Great Chain of Being. This essentially mechanistic approach continued to be relevant throughout the first two industrial revolutions, just concluded, and into the present era of automation, which constitutes, in fact, a third industrial revolution.

However, the social problems that characterize our time, as opposed to the political ones, no longer allow a compartmentalized approach. We are ap-proaching the dawn of a classless society, to which separation into rigid categories is absolutely irrelevant. This shift does not relate more to East than West or vice versa. Castro works in the cañe fields. New York's Mayor Lindsay walks to work during the subway strike. The millionaires eat their lunches at Horn and Hardart's. This sort of populism is a growing tendency rather than a shrinking one.

We sense this in viewing art which seems to belong unnecessarily rigidly to one or another form. We view paintings. What are they, after all? Expensive, handmade objects, intended to ornament the walls of the rich or, through their (or their government's) munificence, to be shared with the large numbers of peo-ple and give them a sense of grandeur. But they do not allow any sense of dialogue.

Pop art? How could it play a part in the art of the future? It is bland. It is puré. It uses elements of common life without comment, and so, by accepting the mis-ery of this life and its aridity so mutely, it condones them. Pop and Op are both dead, however, because they confine themselves, through the media which they employ, to the older functions of art, of decorating and suggesting grandeur, whatever their detailed content or their artists' intentions. None of the ingenious theories of the Mr. Ivan Geldoway combine can prevent them from being colos-sally boring and irrelevant. Milord runs his Mad Avenue gallery, in which he dis-plays his pretty wares. He is protected by a handful of rude footmen who seem to feel that this is the way Life will always be. At his beck and cali is Sir Fretíul Callous, a moderately well-informed high priest, who apparently despises the Fíame he is supposed to tend and therefore prefers anything that thillates him. However, Milord needs his services, since he, poor thing, hasn't the time or the energy to contribute more than his ñame and perhaps his dollars; getting infor-mation and finding out what's going on are simply toooooo exhausting. So, well protected and advised, he goes blissfully through the streets in proper Louis XIVstyle.

This scene is just not characteristic of the painting world as an institution, however. It is absolutely natural to (and inevitable in) the concept of the puré médium, the painting or precious object of any kind. That is the way such objects are marked since that is the world to which they belong and to which they relate.

The sense of "I am the state," however, will shortly be replaced by "After ine the deluge," and, in fact, if the High Art world were better informed, it would real-ize that the deluge has already begun.

Who knows when it began? There is no reason for us to go into history in any detail. Part of the reason that Duchamp's objects are fascinating while Picasso's voice is fading is that the Duchamp pieces are truly between media, between sculpture and something else, while a Picasso is readily classifiable as a painted ornament. Similarly, by invading the land between collage and photography, the Germán John Heartfield produced what are probably the greatest graphics of our century, surely the most powerful political art that has been done to date.

The ready-made or found object, in a sense an intermedium since it was not intended to conform to the puré media, usually suggests this, and therefore sug-gests a location in the field between the general área of art media and those of life media. However, at this time, the locations of this sort are relatively unexplored. as compared with media between the arts. I cannot, for example, ñame work that has consciously been placed in the intermedium between painting and shoes. The closest thing would seem to be the sculpture of Claes Oldenburg, which falls between sculpture and hamburgers or Eskimo Pies, yet it is not the sources of these images themselves. An Oldenburg Eskimo Pie may look something like an Eskimo Pie, yet it is neither edible or cold. There is still a great deal to be done in this direction in the way of opening up aesthetically rewarding possibilities.

In the middle 1950s many painters began to realize the fundamental irrelevance of Abstract Expressioaistu, which was Üre domirant mode at the time. Such painters as Alian Kaprow and Robert Rauschenberg in the United States and Wolf Vostell in Germany turned to collage or, in the latter's case, dé-collage in the sense of making work by adding or removing, replacing and substituting or altering components of a visual work. They began to include increasingly in-congruous objects in their work. Rauschenberg called his constructions *combines* and went so far as to place a stuffed goat—spattered with paint and a rubber tire around its neck—onto one. Kaprow, more philosophical and restless, medi-tated on the relationship of the spectator and the work. He put mirrors into his things so the spectator could feel included in them. That wasn't physical enough. so he made enveloping collages which surrounded the spectator. These he called *environments.* Finally, in the spring of 1958, he began to include live people as part of the collage, and this he called a *happening.*

The proscenium theater is the outgrowth of seventeenth-century ideáis of social order. Yet there is remarkably little structural difference between the dramas of D'Avenant and those of Edward Albee, certainly nothing comparable to the difference in pump construction or means of mass transportation. It would seem that the technological and social implications of the first two industrial revolu-tions have been evaded completely. The drama is still mechanistically divided: there are performers, production people, a sepárate audience and an explicit script. Once started. like Frankenstein's monster, the course of aífairs is unalter-able, perhaps damned by its inability to reflect its surroundings. With our pop-ulistic mentality today, it is difficult to attach importance—other than what we have been taught to attach—to this traditional theater. Ñor do minor innovations do more than provide dinner conversation: this theater is round instead of square, in that one the stage revolves, here the play is relatively senseless and whimsical (Pinter is, after all, our modern J. M. Barrie—unless the honor be-longs more properly to Beckett). Every year fewer attend the professional Broad-way theaters. The shows get sillier and sillier, showing the producers' estímate of our mentality (or is it their own that is revealed?). Even the best of the traditional theater is no longer found on Broadway but at the Judson Memorial Church, some miles away. Yet our theater schools grind out thousands on thou-sands of performing and production personnel, for whom Jobs will simply not exist in twenty years. Can we blame the unions? Or rents and real estáte laxes? Of course not. The subsidized productions, sponsored at such museums as New York's Lincoln Center, are not building up a new audience so much as reculti-vating an oíd one, since the médium of such drama seems weird and artificial in our new social milieu. We need more portability and flexibility, and this the traditional theater cannot provide. It was made for Versailles and for the sedentary Milords, not for motorized life-demons who travel six hundred miles a week. Versailles no longer speaks very loudly to us, since we think at eighty-five miles an hour.

In the other direction, starting from the idea of theater itself, others such as myself declared war on the script as a set of sequential events. Improvisation was no help; performers merely acted in imitation of a script. So I began to work as if time and sequence could be utterly suspended, not by ignoring them (which would simply be illogical) but by systematically replacing them as structural el-ements with change. Lack of change would cause my pieces to stop. In 1958 I wrote a piece, *Stacked Deck,* in which any event can take place at any time, as long as its cue appears. The cues are produced by colored lights. Since the colored lights could be used wherever they were put, and audience reactions were also cuing situations, the performance-audience separation was removed and a hap-pening situation was established, though less visually oriented in its use of its en-vironment and imagery. At the same time, Al Hansen moved into the área from graphic notation experiments, and Nam June Paik and Benjamin Patterson (both in Germany at the time) moved in from varieties of music in which specifically musical events were frequently replaced by nonmusical actions.

Thus the Happening developed as an intermedium, an uncharted land that lies between collage, music, and the theater. It is not governed by rules; each work determines its own médium arid form according to its needs. The concept itself is better understood by what it is not, rather than what it is. Approaching it, we are pioneers again, and shall continué to be so as long as there's plenty of elbow room and no neighbors around for a few miles. Of course, a concept like this is very disturbing to those whose mentality is compartmentalized. *Time, Life* and the High Priests have been announcing the death of Happenings, reg-ularly since the movement gained momentum in the late fifties, but this says more about the accuracy of their information than about the liveliness of the movement.

We have noted the intermedia in the theater and in the visual arts, the Happening, and certain varieties of physical constructions. For reasons of space we cannot take up here the intermedia between other áreas. However, I would like to suggest that the use of intermedia is more or less universal throughout the fine arts, since continuity rather than categorization is the hallmark of our new mentality. There are parallels to the Happening in music, for example, in the work of such composers as Philip Córner and John Cage, who explore the intermedia between music and philosophy, or Joe Jones, whose self-playing musical instru-ments fall into the intermedium between music and sculpture. The constructed music of Emmet Williams and Robert Filliou certainly constitute an intermedium between poetry and sculpture. Is it possible to speak of the use of intermedia as a huge and inclusive movement of which dada, futurism, and surrealism are early phases preceding the huge ground-swell that is taking place now? Or is it more reasonable to regard the use of intermedia an irreversible historical innovation. more comparable to the development of instrumental music than, for example. to the development of romanticism?

BillyKlüver

"The Great Northeastern Power Failure" (1966)

5

Jean Tinguely, Homage to New York. *Photo by David Gahr. Courtesy ofBilly Kliiver.*

"The new ¡nterface I will define is one ¡n which the artist makes active use ofthe inventiveness and skills of an engineer to achieve hís purpose. The artist could not complete his intentions without the help of an engineer. The artist incorporales the work ofthe engineer in the painting *or the sculpture or the performance."*

34 Billy Klüver

« In the late 1950s, the Swedlsh-born engineer BIlly Klüver worked on láser systems for Bell Laboratories ¡n Murray Hill; New Jersey. Klüver, however, was not satisfied by purely scientific pursuits, and his interests led him to explore the artlstic milleu that gave rise to pop art, minimalism, and Happenings a short drive away in New York City. Klüver befrlended the leading exponents of the newarts, which led tocollaborationswith such key figures as Robert Rauschenberg,Jasper Johns, Andy Warhol, and John Cage. He became the chief catalyst for the art and technology movement that was launched dramatically ¡n the spring of 1960, at the Museum of Modern Art, with Jean Tinguely's infamous self-destructing k¡netic sculpture, *Homageto New York.* Klüver's participaron ¡n this work, with its paint bombs, chemical stinks, noisemakers, and fragments of scrap metal, inspired a generation of artists to imagine the possibilities of technology, as the machine destroyed itself, in Klüver's words, "¡n one glorious act of mechanical suicide."

In the 1960s, Klüver, more than anyone, sawthe potential for the integration of art and technology. Inspired by Aristotle's notion of Techne—in which there was no differentiation between the practice of art and science—Klüver proposed the active and *equal* particlpation of the artist and engineer in the creation of the artwork. In this collaboration, he believed that the engineer required the participation of the artist, who, as a "visionary about life" and an active agent of social change, involved the engineer ¡n meaningful cultural dialogue. At the same time, he felt that the artist, ¡n the spirit of Rauschenberg's famous credo "to cióse the gap between art and life," had an obligation to incorpórate technology as an element ¡n the artwork, since technology had become inseparable from our uves.

Shortly after writing this article, Klüver cofounded the now legendary Experiments in Art and Technology (E.A.T.) with Rauschenberg. E.A.T.encouraged the collaboration of artists and engineers across the country ¡n interdisciplinary technology-based art projects. Klüver's work takes on increasing significance as the notion of the synthesis of art and technology has assimilated into the contemporary arts. »

Well, to begin with, the title of my talk is not going to be entirely unrelated to what I am going to say. What I will discuss is a new mode of interaction between science and technology on the one hand and art and life on the other. To use a scientific jargon that is currently in, I will try to define a new interface between these two áreas.

i

Technology has always been closely tied in to the development of art. For Aristotle, Techne means both art and technology. As they became different sub-jects they still fed on each other. New technological discoveries were taken up and used by artists and you are all familiar with the contributions of artists to technology. The contemporary artist reads with ease the technical trade magazines. The new chemical material is hardly developed before it gets used by an artist. Today the artist tends to adopt the new material or the new industrial process as his insignia. We talk about artists in terms that he works in such and such a way or that he uses such and such materials. We hear about artists being poisoned and hurt in their work. In this century, artists have also embraced technology as sub-ject matter: the enthusiasm of the Futurists, the experiments of Dada, the opti-mism of the Bauhaus movement and the Constructivists, all have looked at technology and science and found material for the artists. But for all this inter-est, art remains a passive viewer of technology. Art has only been interested in the fallout, so to speak, of science and technology. The eífect of technology on art can apparently be even a negative one: the invention of the camera helped kill off rep-resentational painting, and we are now witnessing how the computer is about to take care of music and non-representational painting.

The new interface I will define is one in which the artist makes active use of the inventiveness and skills of an engineer to achieve his purpose. The artist could not complete his intentions without the help of an engineer. The artist in-^uipuidics uic worK oí tne engineer in the painting or the sculpture or the performance. A characteristic of this kind of interaction is that generally only one work of art results. In other words, the engineer is notjust inventing a new and special process for the use of the artist. He does notjust teach the artist a new skill which the artist can use to extract new aestheüc variations. Technology is well aware of its own beauty and does not need the artist to elabórate on this. I will argüe that the use of the engineer by the artist is not only unavoidable but nec-essary.

Before I try to justify why I believe that this interface exists and why the interaction between artists and engineers will become stronger, let me give you a few simple examples of what I mean in terms of works that already exist. I shall be modest and limit myself to use examples from my own experience. But there exist several others.

You probably have heard about Jean Tinguely's self-destroying machine, *Hommage to New York,* which more or less destroyed itself on March 17,1960, in the sculpture garden of the Museum of Modern Art in New York. In retrospect I thirik my modest contribution to the machine was to visit garbage dumps in

New Jersey to pick up bicycle wheels and to truck them to 53rd Street. However. there were a few technical ideas hidden in Tinguely's machine which incidentally were mainly the contributions of my technical assistant at the time, Harold Hodges. There were about eight electrical circuits in the machine which closed successively as the machine progressed toward its ultimate fate. Motors would start, smoke would come out, smaller machines would leave the big one to escape. In order to make the main structure collapse, Harold had devised a scheme using supporting sections of Wood's metal which would melt from the heat of over-heated resistors. At another point this method was used to light a candle. Con-trary to what I hear frequently said, Tinguely's machine did not contain mam o: these technical links. It was mostly Tinguely's motors that did it.

A better example is two neón light power supplies that we made for two paintings by Jasper Johns. In one case, the light was the letter A, in the other the letter R. What was new was that Johns wanted no cords to the painting. To stack up batteries to 1200 volts would have been messy, dangerous and impractical. Se we started out with 12 volts of rechargeable batteries and devised a multivibra-tor circuit which, together with a transformer, would give us 1200 volts. The technical equipment, all 400 dollars' worth of it, was mounted behind John's painting.

My final example is Rauschenberg's large sculpture *Oracle,* which was shown in New York last year. It was the result of work carried out over three years dur-ing which time two complete technical systems were fimshed and junked. The final system enables the sound from five AM radios to be heard from each of the five sculptures in the group, but with each radio being controlled from a central control unit, in one of the sculptures. There are no connecting wires between the sculptures and they are all freely movable, on wheels.

All these examples have one thmg in common: they are ndiculous from an en-gineer's point of view. Why would anyone want to spend 9000 dollars to be abic to control five AM radios simultaneously, in one room? I want to emphasize that the examples contain very simple engineering and should not be taken as ven' original. But each of the projects required an engineer or a technically skilled per-son to achieve what the artist wanted. And an important point is that the artiv could not be quite sure about the outcome.

We have been taught by Robert Rauschenberg that the painting is an objeci among other objects, subjected to the same psychological and physical influences as other objects. During a musical piece byjohn Cage, we are forced to ac-cept the equality of all the sounds we hear as part of the composition. In his happenings, Claes Oldenburg lets the actors play themselves although in most instances the actors are unaware of this. He writes his Happenings with a particular person in mind, allowing the specific shyness, nervousness, sensuality of the person to become part of the Happening. The tradition in art can, therefore, not tell us anything else but that the technical elements involved in the works I have described are just as much a part of the work of art as the paint in the painting. It is impossible to treat the sound as part of *Oracle* and not the radios. Jasper Johns has already shown us the backside of the canvas and I am afraid he will have to accept the not-so-elegant backsides of *Field Painting* and *Zone* as well. But if the radios and the amplifiers are part of the work—what about the engineer who designs them? In the same way as Oldenburg works with the peculiarities of people in his Happenings, the artist has to work with the peculiarities and the for-eign mode of operation of the engineer. On the basis of this observation, I hereby declare myself to be a work of art—or rather an integral part of the works of art I have just described. I am definitely not a violin player who interprets and feels for the work of his master. I know nothing about art or the artists involved. I am an engineer and as such, only raw material for the artist.

But how can I claim that this new interface between art and technology does in fact exist? Maybe I wanted to become a work of art and devised this inge-nious scheme for my own ends? Well, I think that we don't have to look too far. We all know how technology has become part of our lives. And now we can see absolutely no reason why it should not become more so. No sound has been heard from another culture to oppose Western technology. The faster the un-derdeveloped countries can have it, the faster they want it. On the other end of the spectrum, we now have systems where we don't know quite where the machine ends and the human being begins. I am thinking of the space program which has introduced the new and maybe inhuman objective: the system has to work, no failures are allowed, no personal emotions or mistake may interfere with the success of the project. The space program is developing a new man-agerial type which is totally responsible. I read recently that President Johnson has let the contract to solve the Appalachian problem go to the electronics in-dustry. We are now getting the fallout from Cape Kennedy and can expect more.

The great initiator of all this technological soul-searching is the computer. Laboriously we are translating every aspect of human activity into computer language. In fact, I believe the computer will turn out to be the greatest psychoanalyst of all times. Now where does all this leave us? The engineers may be psychoanalysts but they are not visionaries. John Cage has recently written a wonderful article called "How to Improve the World." As a blind engineer, one of his observations gave me a realjolt. Cage points out that there exist systems of interacción between human beings which work without any pólice or power structure whatsoever. In fact, there are hundreds of agreements between the countries of the world that work perfectly well. In particular, technological ques-tions are dealt with without any complications. It seems that technology breeds agreement. This is such a simple observation that it frightens you that you did not think of it. I believe that Cage's discovery fullyjustifies the statement that technology will forcé the solution of such problems as food distribution and housing. There is no other stable optimum but to give people food and housing. The Dadaists' suggestion of free food and Buckminster Fuller's suggestion of free housing for the people of the world will happen. But the alternatives that the en-gineer can imagine for the full use of the fantastic capacity of technology are even so few and limited. He is, as I said, no visionary about life. But the artist is a visionary about life. Only he can créate disorder and still get away with it. Only he can use technology to its fullest capacity. John Cage has suggested: Let the engi-neer take care of order and art (in the traditional sense) and let the artists take care of disorder and life. And I am adding technology. This to sum up: First the artists have to créate with technology because technology is becoming inseparable from our lives. "Technology is the extensión of our nervous system," as McLuhan says. Second, the artists should use technology because technology needs the artists. Technology needs to be revealed and looked at—much like we undress a woman.

The artist's work is like that of a scientist. It is an investigation which may or may not yield meaningful results; in many cases we only know many years later. What I am suggesting is that the use of the engineer by the artist will stimulate new ways of looking at technology and dealing with life in the future.

What about power failure? I wish we knew more about what happened. We heard a lot about how people became friendly and helped each other out. The whole thing could have been an artist's idea—to make us aware of something. In the future there will exist technological systems as complicated and as large as the Northeastern power grid whose solé purpose will be to intensify our lives through increased awareness.

Nam JungPaik

"Cybernated Art" (1966) "Artand Satellite" (1984)

6

\amJunePaik, Opera Sextronique. *Photo by Ludwig Winterhalter. Courtesy ofNam June Paik.*

"There ¡s no rewind button on the Betamax oflife."

40 Nam June Paik

« The Korean born Nam June Paik's formative years were grounded ¡n the study of rigorous post-Webern, twelve-tone music composition. After meeting the iconoclastic American composer John Cage at the Darmstadt Summer School of Music ¡n 1958, Paik turned to performance art and mixed-media works that challenged his classical roots. Most important, Paik embraced the médium of televisión, and became the founding father of video art. H is long and prolific relationship with electronic media began notably with the cellist Charlotte Moorman, ¡n controversial performance works such as *Opera Sextronique* (1967). Paik's oeuvre later included televisión sculpture, satellite art, robotíc devices, and giant video walls with synthesized imagery pulsating from stacks of cathode-ray tubes.

In the brief, mischievously elfin manifestó "Cybernated Art," Paik suggests that art should embrace the technologies of an information society. Paik presents himself as artist-shaman, synthesizing art and technology in an effort to exorcise the demons of a mass-consumer, technology-obsessed society. Paik uses rejected media artifacts in his work, such as vintage televisión sets; his video works, with their liberal doses of "cybernated shock and catharsis," are poignantly cynical pieces that comment on an American techno-culture dominated by starry-eyed optimists.

In the latter essay, "Art and Satellite," he explains that the material of the ¡nformation age—the raw data, the continuousflow of contení—is becoming an intrinsic element of his artwork. He sees in the satellite, the most advanced communicatjqns technoloqy, of its day^an opportunity, to connect minds and encourage new ways of thinking.Through the connectivity of a "cybernated society," a work of art can become dynamic, always changing, as data flows through the wired network and across our screens'. As the artwork incorporates the unending flow and restless nature of information itself, transcending geographical boundaries, ¡t brings about a "synthesis" of all cultures across borders. »

cybernated art (1966)

Cybernated art is very importan!, but art for cybernated life is more important, and the latter need not be cybernated. (Maybe George Brecht's simplissimo is the most adequate.)

» But if Pasteur and Robespierre are right that we can resist poison only through certain built-in poison, then some specific frustrations, caused by cybernated life, require accordingly cybernated shock and catharsis. My everyday work with videotape and the cathode-ray tube convinces me of this.

Cybernetics, the science of puré relations, or relationship itself, has its origin in karma. Marshall McLuhan's famous phrase "Media is message" was formulated by Norbert Wiener in 1948 as "The signal, where the message is sent, plays equally important role as the signal, where message is not sent."

As the Happening is the fusión of various arts, so cybernetics is the exploitation of boundary regions between and across various existing sciences.

" Newton's physics is the mechanics of power and the unconciliatory two-party system, in which the strong win over the weak. But in the 1920s a Germán genius put a tiny third-party (grid) between these two mighty poles (cathode and anode) in a vacuum tube, thus enabling the weak to win over the strong for the first time in human history. It might be a Buddhistic "third way," but anyway this Germán invention led to cybernetics, which carne to the world in the last war to shoot down Germán planes from the English sky.

The Buddhists also say

Karma is samsara
Relationship is metempsychosis

We are in open circuits

art and satellite (1984)

At the turn of our century, the French mathematician Henri Poincaré said the fol-lowing thing.... (Yes, it was in the midst of so-called material progress and the
discovery of new Things) Poincaré pointed out that what was being discovered was not new things but merely the new relationships between things already existing.
We are again in the fin de siécle . . . this time we are discovering much nCW

software ... which are not new things but new thinks ... and again we are dis-covering and even weaving new relationships between many thinks and minds... we are already knee-deep in the post industrial age. The satellite, especially the
live two-way satellite, is a very powerful tool for this human Videosphere

It is said that all the sciences can trace their roots to Aristotle: but the science of cosmic aesthetics started with Sarutobi Sasuke, a famous *ninja* (a samurai who mastered many fantastic arts, including that of making himself invisible, chiefly to spy upon an enemy). The first step for a *ninja.* is learning how to shorten distances by shrinking the earth, that is, how to transcend the law of gravity. For the satellite, this is a piece of cake. Sojust as Mozart mastered the newly invented clarinet, the satellite artist must compose his art from the begin-ning suitable to physical conditions and grammar. Satellite art in the superior sense does not merely transmit existing symphonies and operas to other lands. It must consider how to achieve a two-way connection between opposite sides of the earth; how to give a conversational structure to the art; how to master dif-ferences in time; how to play with improvisation, in-determinism, echos, feed-backs, and empty spaces in the Cagean sense; and how to instantaneously manage the differences in culture, preconceptions, and common sense that exist between various nations. Satellite art must make the most of these elements (for they can become strengths or weaknesses), creating a multitemporal, multispatial sym-phony....

There is no rewind button on the BETAMAX of life. An important event takes place only once. The free deaths (of Sócrates, Christ, Bo Yi and Shu Qi) that be-came the foundations for the morality of three civilizations occurred only once. The meetings of person and person, of person and specific era are often said to take place "one meeting-one life," but the *bundle oísegments* of this existence (if *segments* can come in *bundles)* has grown much thicker because of the satellite. The thinking process is the jumping of electrical sparks across the synapses between brain cells arranged in multilayered matrices. Inspiration is a spark shooting offin an unexpected direction and landing on a point in some córner of the matrix. The satellite will accidentally and inevitably produce unexpected meetíngs of person and person and will enrich the synapses between the brain cells of mankind. Thoreau, the author of *Walden, Life in the Woods,* and a nineteenth-century forerunner of the hippies, wrote, "The telephone company is trying to connect Maine and Tennessee by telephone. Even if it were to suc-ceed, though, what would the people say to each other? What could they pos-sibly find to talk about?" Of course, history eventually answered Thoreau's questions (silly oncs, at that). There developed a feedback (or, to use an older term, dialectic) of new contacts breeding new contents and new contents breeding new contacts....

Thanks to the satellite, the mysteries of encounters with others (chance meet-ings) will accumulate in geometric progression and should become the main nonmaterial product of post-industrial society. God created love to propágate the human race, but, unawares, man began to love simply to love. By the same logic, although man talks to accomplish something, unawares, he soon begins to talk simply to talk....

part II

Interactívity

Norbert Wiener

"Cybernetícs in History," *The Human Use of Human Beings* (1954)

7

Norbert Wiener atMIT. Courtesy ofMIT Computer Museum.

"Soc/efy *can only be understood through a study ofthe messages and the communication fadüties which belong to ¡t; and that ¡n the Mure development of these messages and communícatlon facilities, messages between man and machines, between machines and man, and between machine and machine, are destined to play an ever increasing part."*

« Norbert Wiener, a Hungarian-born mathematician, electrical engineer, and Communications specialist, wrote about the nature of human-machine communication in his landmark treatise of 1948, *Cybernetics.* In an attempt to make his theories on information science and machine control accessible to a broader public, two years later he published *The Human Use of Human Beings,* drawing from sociology to theorize about how people might interact and coexist with computers, then revised the book for a new edition in 1954.

Wiener claimed that the quality of man-machine communication influences man's innerwell-being. Histheory of cybernetics was meantto improve the quality of life in a technological society, where people are increasingly reliant on machines, and where interactions with machines are the norm.

Wiener defined cybernetics as the science of transmitting messages between man and machine, or from machine to machine.The term *cybernetics* has its roots in the Greek word for "steersman" or "governor," and Wiener's use of it suggests how people interact with machines through a controlling device, such as a steering mechanism. Driving a car, passing through an automatic door, or clicking a mouse are all cybernetic actions. Wiener's remarkable insight, which is the premise behind all human-computer interactivity and interface design, is that human communication should be a model for human-machine and machine-to-machine interactions. Wiener points out that the quality of datatransmission between man and machine is affected by such factors as feedback, noise, and entropy. As he succinctly puts it, "the fact that the signal in its intermedíate stages has gone through a machine rather than through a person is irrelevant." >>

OIIICe the end of World War II, I have been working on the many ramifications of the theory of messages. Besides the electrical engineering theory of the transmission of messages, there is a larger field which includes not only the study of language but the study of messages as a means of controlling machinery and society, the development of computing machines and other such autómata, certain reflections upon psychology and the nervous system, and a tentative new theory of scientific method. This larger theory of messages is a probabilistic theory, an intrinsic part of the movement that owes its origin to Willard Gibbs.

Until recently, there was no existing word for this complex of ideas, and in order to embrace the whole field by a single term, I felt constrained to invent one. Hence "Cybernetics," which I derived from the Greek word *kubernétés,* or "steersman," the same Greek word from which we eventually derive our word "governor." Incidentally, I found later that the word had already been used by Ainpére with reference to political science, and had been introduced in another context by a Polish scientist, both uses dating from the earlier part of the nine-teenth century.

I wrote a more or less technical book entitled *Cybernetics* which was published in 1948. In response to a certain demand for me to make its ideas accept-able to the lay public, I published the first edition of *The Human Use of Human Beings* in 1950. Since then the subject has grown from a few ideas shared by Drs. Claude Shannon, Warren Weaver, and myself into an established región of re-search. Therefore, I take this opportunity occasioned by the reprinting of my book to bring it up to date, and to remove certain defects and inconsequentiali-ties in its original structure.

In giving the definition of Cybernetics in the original book, I classed communication and control together. Why did I do this? When I communicate with another person, I impart a message to him, and when he communicates back with me he returns a related message which contains information primarily ac-cessible to him and not to me. When I control the actions of another person, I communicate a message to him, and although this message is in the imperative mood, the technique of communication does not differ from that of a message of fact. Furthermore, if my control is to be effective I must take cognizance of any messages from him which may indicate that the order is understood and has been obeyed.

It is the thesis of this book that society can only be understood through a study of the messages and the communication facilities which belong to it; and that in the future development of these messages and communication facilities, messages between man and machines, between machines and man, and between machine and machine are destined to play an ever-increasing part.

When I give an order to a machine, the situation is not essentially different from that which arises when I give an order to a person. In other words, as far as my consciousness goes I am aware of the order that has gone out and of the sig-nal of compliance that has come back. To me, personally, the fact that the signal in its intermediate stages has gone through a machine rather than through a person is irrelevant and does not in any case greatly change my relation to the signal. Thus the theory of control in engineering, whether human or animal or mechanical, is a chapter in the theory of messages.

Naturally there are detailed differences in messages and in problems of control, not only between a living organism and a machine, but within each narrower class of beings. It is the purpose of Cybernetics to develop a language and techniques that will enable us indeed to attack the problem of control and com-munication in general, but also to find the proper repertory of ideas and techniques to classify their particular manifestations under certain concepts.

The commands through which we exercise our control over our environment are a kind of information which we impart to it. Like any form of information, these commands are subject to disorganization in transit. They generally come through in less coherent fashion and certainly not more coherently than they were sent. In control and communication we are always fighting nature's tendency to degrade the organized and to destroy the meaningful; the tendency, as Gibbs has shown us, for entropy to increase.

Much of this book concerns the limits of communication within and among individuáis. Man is immersed in a world which he perceives through his sense or-gans. Information that he receives is coordinated through his brain and nervous system until, after the proper process of storage, collation, and selection, it emerges through effector organs, generally his muscles. These in turn act on the external world, and also react on the central nervous system through receptor organs such as the end organs of kinaesthesia; and the information received by the kinaesthetic organs is combined with his already accumulated store of information to influence future action.

Information is a ñame for the content of what is exchanged with the outer world as we adjust to it, and make our adjustment felt upon it. The process of re-ceiving and of using information is the process of our adjusting to the contin-gencies of the outer environment, and of our living effectively within that environment. The needs and the complexity of modern life make greater de-mands on this process of information than ever before, and our press, our mu-seums, our scientific laboratories, our universities, our libraries and textbooks, are obliged to meet the needs of this process or fail in their purpose. To live effectively is to live with adequate information. Thus, communication and control belong to the essence of man's inner life, even as they belong to his life in society....

Messages are themselves a form of pattern and organization. Indeed, it is possible to treat sets of messages as having an entropy like sets of states of the external world. Just as entropy is a measure of disorganization, the information carried by a set of messages is a measure of organization. In fact, it is possible to interpret the information carried by a message as essentially the negative of its entropy, and the negative logarithm of its probability. That is, the more probable the message, the less information it gives. Clichés, for example, are less illuminating

than grcat poems. . . .

Let us consider the activity of the little figures which dance on the top of a music box. They move in accordance with a pattern, but it is a pattern which is set in advance, and in which the past activity of the figures has practically noth-ing to do with the pattern of their future activity. The probability that they will diverge from this pattern is nil. There is a message, indeed; but it goes from the machinery of the music box to the figures, and stops there. The figures them-selves have no trace of communication with the outer world, except this one-way stage of communication with the preestablished mechanism of the music box. They are blind, deaf, and dumb, and cannot vary their activity in the least from the conventionalized pattern.

Contrast with them the behavior of man, or indeed of any moderately intelligent animal such as a kitten. I cali to the kitten and it looks up. I have sent it a message which it has received by its sensory organs, and which it registers in ac-tion. The kitten is hungry and lets out a pitiful wail. This time it is the sender of a message. The kitten bats at a swinging spool. The spool swings to its left, and the kitten catches it with its left paw. This time messages of a very complicated nature are both sent and received within the kitten's own nervous system through certain nerve end-bodies in its joints, muscles, and tendons; and by means of nervous messages sent by these organs, the animal is aware of the actual position and tensions of its tissues. It is only through these organs that anything like a manual skill is possible.

I have contrasted the prearranged behavior of the little figures on the music box on the one hand, and the contingent behavior of human beings and animáis on the other. But we must not suppose that the music box is typical of all machine behavior.

The older machines, and in particular the older attempts to produce autómata, did in fact function on a closed clockwork basis. But modern automatic machines such as the controlled missile, the proximity fuse, the automatic door opener, the control apparatus for a chemical factory, and the rest of the modern armory of automatic machines which perform military or industrial functions possess sense organs; that is, receptors for messages coming from the outside. These may be as simple as photoelectric cells which change electrically when a light falls on them, and which can tell light from dark, or as complicated as a televisión set. They may measure a tensión by the change it produces in the con-ductivity of a wire exposed to it, or they may measure temperature by means of a thermocouple, which is an instrument consisting of two distinct metáis in con-tact with one another through which a current flows when one of the points of contact is heated. Every instrument in the repertory of the scientific-instrument maker is a possible sense organ, and may be made to record its reading remotely through the intervention of appropriate electrical apparatus. Thus the machine which is conditioned by its relation to the external world, and by the things hap-pening in the external world, is with us and has been with us for some time.

The machine which acts on the external world by means of messages is also familiar, The automatic photoelectric door opener is known to every person who has passed through the Pennsylvania Station in New York, and is used in many other buildings as well. When a message consisting of the interception of a beam of light is sent to the apparatus, this message actuales the door, and opens it so that the passenger may go through.

The steps between the actuation of a machine of this type by sense organs and its performance of a task may be as simple as in the case of the electric door; or it may be in fact of any desired degree of complexity within the limits of our en-gineering techniques. A complex action is one in which the data introduced. which we cali the *input,* to obtain an eífect on the outer world, which we cali the *output,* may involve a large number of combinations. These are combinations. both of the data put in at the moment and of the records taken from the past stored data which we cali the *memory.* These are recorded in the machine. The most complicated machines yet made which transform input data into output data are the high-speed electrical computing machines, of which I shall speak later in more detail. The determination of the mode of conduct of these machines is given through a special sort of input, which frequently consists of punched cards or tapes or of magnetized wires, and which determines the way in which the machine is going to act in one operation, as distinct from the way ir. which it might have acted in another. Because of the frequent use of punched or magnetic tape in the control, the data which are fed in, and which indícate the mode of operation of one of these machines for combining information, are calleo the *taping.*

I have said that man and the animal have a kinaesthetic sense, by which thev keep a record of the position and tensions of their muscles. For any machine subject to a varied external environment to act effectively it is necessary that information concerning the results of its own action be furnished to it as part of the information on which it must continué to act. For example, if we are running ar. elevator, it is not enough to open the outside door because the orders we have given should make the elevator be at that door at the time we open it. It is in:-portant that the reléase for opening the door be dependent on the fact that *ir.-.* elevator is actually at the door; otherwise something might have detained it. ar.: the passenger might step into the empty shaft. This control of a machine on *is.-*

basis of its *actual* performance rather dian its *expected* performance is known as *feedback,* and involves sensory members which are actuated by motor members and perform the function *of tell-tales* or *monitors*—that is, of elements which indícate a performance. It is the function of these mechanisms to control the me-chanical tendency toward disorganization; in other words, to produce a temporary and local reversal of the normal direction ofentropy.

I have just mentioned the elevator as an example of feedback. There are other cases where the importance of feedback is even more apparent. For example, a gun-pointer takes information from his instruments of observation, and conveys it to the gun, so that the latter will point in such a direction that the missile will pass through the moving target at a certain time. Now, the gun itself must be used under all conditions of weather. In some of these the grease is warm, and the gun swings easily and rapidly. Under other conditions the grease is frozen or mixed with sand, and the gun is slow to answer the orders given to it. If these orders are reinforced by an extra push given when the gun fails to respond easily to the orders and lags behind them, then the error of the gun-pointer will be de-creased. To obtain a performance as uniform as possible, it is customary to put into the gun a control feedback element which reads the lag of the gun behind the position it should have according to the orders given it, and which uses this dif-ference to give the gun an extra push.

It is truc that precautions must be taken so that the push is not too hard, for if it is, the gun will swing past its proper position, and will have to be pulled back in a series of oscillations, which may well become wider and wider, and lead to a disastrous instability. If the feedback system is itself controlled—if, in other words, its own entropic tendencies are checked by still other controlling mechanisms—and kept within limits sufficiently stringent, this will not occur, and the existence of the feedback will increase the stability of performance of the gun. In other words, the performance will become less dependent on the frictional load; or what is the same thing, on the drag created by the stiffness of the grease.

Something very similar to this occurs in human action. If I pick up my cigar, I do not will to move any specific muscles. Indeed in many cases, I do not know what those muscles are. What I do is to turn into action a certain feedback mech-anism; namely, a reflex in which the amount by which I have yet failed to pick up the cigar is turned into a new and increased order to the lagging muscles, whichever they may be. In this way, a fairly uniform voluntary command will en-able the same task to be performed from widely varying initial positions, and ir-respective of the decrease of contracción diie *to fatigue of the muscles. Similarly,* when I dríve a car, I do not follow out a series of commands dependent simply on a mental image of the road and the task I am doing. If I fmd the car swervingtoo much to the right, that causes me to pulí it to the left. This depends on theactual performance of the car, and not simply on the road; and it allows me todrive with nearly equal efficiency a light Austin or a heavy truck, without havingformed sepárate habits for the driving of the two

It is my thesis diat the physical functioning of the living individual and the operation of some of the newer communication machines are precisely parallel in their analogous attempts to control entropy through feedback. Both of them have sensory receptors as one stage in their cycle of operation: that is, in both of them there exists a special apparatus for collecting information from the outer world at low energy levéis, and for making it available in the operation of the individual or of the machine. In both cases these external messages are not taken *neat.* but through the internal transforming powers of the apparatus, whether it be alive or dead. The information is then turned into a new form available for the fur-ther stages of performance. In both the animal and the machine this performance is made to be effective on the outer world. In both of them, their *performed* ac-tion on the outer world, and not merely their *intended* action, is reported back to the central regulatory apparatus. This complex of behavior is ignored by the av-erage man, and in particular does not play the role that it should in our habitua-analysis of society; for just as individual physical responses may be seen from this point of view, so may the organic responses of society itself. I do not mean that the sociologist is unaware of the existence and complex nature of Communications in society, but until recently he has tended to overlook the extent to whicr. they are the cement which binds its fabric together.

We have seen in this chapter the fundamental unity of a complex of ideas which until recently had not been sufficiently associated with one another. namely, the contingent view of physics that Gibbs introduced as a modifica tío: of the traditional, Newtonian conventions, the Augustinian attitude toward order and conduct which is demanded by this view, and the theory of the messair among men, machines, and in society as a sequence of events in time which- ¡ though it itself has a certain contingency, strives to hold back nature's tendency toward disorder by adjusting its parts to various purposive ends.

J.C.R. Licklider

"Man-Computer Symbiosis" (1960)

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J.C.R. Licklider. Courtesy of MIT Computer Museum..

"The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today."

« Inthe late 1950s,J.C.R, Licklider was one of the few scientists who sawthe computer's potential as a collaborative partner in the creative process. In his book *Librarles of the Future* he proposed how computers networked ¡n a system could lead to a new kind of "thinking center." During his tenure at the United States govemment's Advanced Research Projects Agency (ARPA) in the 1960s, Licklider had the visión to support controversial but critical research that led to the rise of human-computer interactivity and the personal computer. Lickiider's own research on computer networking was a catalyst for the creation of the Internet (originally known as "ARPANET") in 1969.

With this article, Licklider fundamentally changed howwe interact with computers by proposing the nove! ¡dea of a symbiotic relationship between man and machine.The computer's then typical role was as a subservient device that per-formed data operations and mechanical calculations. Licklider suggested that a computer could be more effective as a collaborator, and that this interaction would yield results well beyond what people could achieve on their own. He saw the potential for a dialogue between man and machine, a symbiotic partnership that would unleash tremendous creative potential, made possible by the ease, im-mediacy, and flexibility of a keyboard and real-time graphics display. This fore-sight was extraordinary considering that uMan-Computer Symbiosis" was written when computers were excruciatingly slow and clumsy, with mainframe systems using punch card input and teletype output the norm. »

SUMMARY

Man-computer symbiosis is an expected development in cooperative interaction between men and electronic computers. It wül involve very cióse coupling between the human and the electronic members of the partnership. The main aims are (1) to let computers facilítate formulative thinking as they now facilítate the so-lution of formulated problems, and (2) to enable men and computers to cooper-ate in making decisions and controlling complex situations without inflexible dependence on predetermined programs. In the anticipated symbiotic partnership, men will set the goals, formúlate the hypotheses, determine the criteria, and perform the evaluatións. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and sci-entific thinking. Preliminary analyses indícate that the symbiotic partnership will perform intellectual operations much more effectively than man alone can perform them. Prerequisites for the achievement of the effective, cooperative association

include developments in computer time sharing, in memory componente, in memory organization, in programming languages, and in input and output equipment.

1 introduction

1.1 Symbiosis

The fig tree is pollinated only by the insect *Blastophaga grossorun.* The larva of the insect lives in the ovary of the fig tree, and there it gets its food. The tree and the insect are thus heavily interdependent: the tree cannot reproduce without the insect; the insect cannot eat without the tree; together, they constitute not only a viable but a productive and thriving partnership. This cooperative "living together in intímate association, or even cióse unión, of two dissimilar organisms" is called symbiosis.[1]

"Man-computer symbiosis" is a subclass of man-machine systems. There are many man-machine systems. At present, however, there are no man-computer symbioses. The purposes of this paper are to present the concept and, hopefully, to foster the development of man-computer symbiosis by analyzing some problems of interaction between men and computing machines, calling attenü'on to applicable principies of man-machine engineering, and pointing out a few questions to which research answers are needed. The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today.

1.2 Between "Mechanically Extended Man" and "Artificial Intelligence"

As a concept, man-computer symbiosis is different in an important way from what North[2] has called "mechanically extended man." In the man-machine systems of the past, the human operator supplied the initiative, the direction, the in-tegration, and the criterion. The mechanical parts of the systems were mere extensions, first of the human arm, then of the human eye. These systems certainly did not consist of "dissimilar organisms living together..." There was only one kind of organism—man—and the rest was there only to help him.

In one sense of course, any man-made system is intended to help man, to help a man or men outside the system. If we focus upon the human operator within the system, however, we see that, in some áreas of technology, a fantastic change has taken place during the last few years. "Mechanical extensión" has given way to replacement of men, to automation, and the men who remain are there more to help than to be helped. In some instances, particularly in large computer-centered information and control systems, the human operators are responsible mainly for functions that it proved infeasible to automate. Such systems ("hu-manly extended machines," North might cali them) are not symbiotic systems. They are "semi-automatic" systems, systems that started out to be fully auto-matic but fell short of the goal.

Man-computer symbiosis is probably not the ultimate paradigm for complex technological systems. It seems entirely possible that, in due course, elec-tronic or chemical "machines" will outdo the human brain in most of the functions we now consider exclusively within its province. Even now, Gelernter's IBM-704 program for proving theorems in plañe geometry proceeds at about the same pace as Brooklyn high school students, and makes similar errors.[3] There are, in fact, severa! theorem-proving, problem-solving, chess-playing, and pattern-recognizing programs (too many for complete reference)[4] capable of rivaling human intellectual performance in restricted áreas; and Newell, Simón, and Shaw's[5] "general problem solver" may remove some of the restrictions. In short, it seems worthwhile to avoid argument with (other) enthusiasts for artificial in-telligence by conceding dominance in the distant future of cerebration to machines alone. There will nevertheless be a fairly long interim during which the main intellectual advances will be made by men and computers working together in intímate association. A multidisciplinary study group, examining future re-search and development problems of the Air Forcé, estimated that it would be 1980 before developments in artificial intelligence make it possible for machines alone to do much thinking or problem solving of military significance. That would leave, say, five years to develop man-computer symbiosis and 15 years to use it. The 15 may be 10 or 500, but those years should be intellectually the most creative and exciting in the history of mankind.

2 aims of man-computer symbiosis

Present-day computers are designed primarily to solve preformulated problems or to process data according to predetermined procedures. The course of the computation tnay be conditional upon results obtained during the computation, but all the alternatives must be foreseen in advance. (If an unforeseen alternative arises, the whole process comes to a halt and awaits the necessary extensión of the program.) The requirement for preformulation or predetermination is some-times no great disadvantage. It is often said that programming for a computing machine forces one to think clearly, that it disciplines the thought process. If the user can think his problem through in advance, symbiotic association with a computing machine is not necessary.

However, many problems that can be thought through in advance are very dif-ficult to think through in advance. They would be easier to solve, and they could be solved faster, through an intuitively guided trial-and-error procedure in which the computer cooperated, turning up flaws in the reasoning or revealing unex-pected turns in the solution. Other problems simply cannot be formulated with-out computing-machine aid. Poincaré anticipated the frustration of an important group of would-be computer users when he said, "The question is not, 'What is the answer?' The question is, 'What is the question?' " One of the main aims of man-computer symbiosis is to bring the computing machine effectively into the formulative parts of technical problems.

The other main aim is closely related. It is to bring computing machines effectively into processes of thinking that must go on in "real time," time that moves too fast to permit using computers in conventional ways. Imagine trying, for ex-ample, to direct a battle with the aid of a computer on such a schedule as this. You formúlate your problem today. Tomorrow you spend with a programmer. Next week the computer devotes 5 minutes to assembling your program and 47 sec-onds to calculating the answer to your problem. You get a sheet of paper 20 feet long, full of numbers diat, instead of providing a final solution, only suggest a tac-tic that should be explored by simulation. Obviously, the battle would be over be-fore the second step in its planning was begun. To think in interaction with a computer in the same way that you think with a colleague whose competence supplements your own will require much tighter coupling between man and machine than is suggested by the example and than is possible today.

3 need for computer participation in formulative and real-time thinking

The preceding paragraphs tacitly made the assumption that, if they could be in-troduced effectively into the thought process, the functions that can be performed by data-processing machines would improve or facilítate thinking and problem solving in an importan! way. That assumption may require justification.

3.1 A Preliminary and Informal Time-and-Motion Analysis of Technical Thinking

Despite the fact that there is a voluminous literature on thinking and problem solving, including intensive case-history studies of the process of invention, I could find nothing comparable to a time-and-motion-study analysis of the mental work of a person engaged in a scientific or technical enterprise. In the spring and summer of 1957, therefore, I tried to keep track of what one moderately technical person actually did during the hours he regarded as devoted to work. Although I was aware of the inadequacy of the sampling, I served as my own subject.

It soon became apparent that the main thing I did was to keep records, and the project would have become an infinite regress if the keeping of records had been carried through in the detall envisaged in the initial plan. It was not. Nev-ertheless, I obtained a picture of my activities that gave me pause. Perhaps my spectrum is not typical—I hope it is not, but I fear it is.

About 85 percent of my "thinking" time was spent getting into a position to think, to make a decisión, to learn something I needed to know. Much more time went into finding or obtaining information than into digesting it. Hours went into the plotting of graphs, and other hours into instructing an assistant how to plot. When the graphs were finished, the relations were obvious at once, but the plotting had to be done in order to make them so. At one point, it was necessary to compare six experimental determinations of a function relating speech-intelligibility to speech-to-noise ratio. No two experimenters had used the same definition or measure of speech-to-noise ratio. Several hours of calculating were required to get the data into comparable form. When they were in comparable form, it took only a few seconds to determine what I needed to know.

Throughout the period I examined, in short, my "thinking" time was devoted mainly to activities that were essentially clerical or mechanical: searching. calculating, plotting, transforming, determining the logical or dynamic consequences of a set of assumptions or hypotheses, preparing the way for a decisión or an insight. Moreover, my cholees of what to attempt and what not to attempt were determined to an embarrassingly great extent by considerations of clerical feasibility, not intellectual capability.

The main suggestion conveyed by the íindings just described is that the operations that fill most of the time allegedly devoted to technical thinking are operations that can be performed more effectively by machines than by men. Severe problems are posed by the fact that these operations have to be performed upon diverse variables and in unforeseen and continually changing sequences. If those problems can be solved in such a way as to créate a symbiotic relation between a man and a fast information-retrieval and data-processing machine, however, it seems evident that the cooperative interaction would greatly improve the thinking process.

It may be appropriate to acknowledge, at this point, that we are using the temí "computer" to cover a wide class of calculating, data-processing, and information-storage-and-retrieval machines. The capabilities of machines in this class are increasing almost daily. It is therefore hazardous to make general statements about capabilities of the class. Perhaps it is equally hazardous to make general statements about the capabilities of men. NevertheJess, certain genotypic differences in capability between men and computers do stand out, and they have a bearing on the nature of possible man-computer symbiosis and the po-tential valué of achieving it.

As has been said in various ways, men are noisy, narrow-band devices, but their nervous systems have very many parallel and simultaneously active channels. Relative to men, computing machines are very fast and very accurate, but they are constrained to perform only one or a few elementary operations at a time. Men are flexible, capable of "programming themselves contingently" on the basis of newly received information. Computing machines are single-minded, constrained by their "pre-programming." Men naturally speak redundan! languages organized around unitary objects and coherent actions and employing 20 to 60 elementary symbols. Computers "naturally" speak nonredundant languages, usually with only two elementary symbols and no inherent appreciation either of unitary objects or of coherent actions.

To be rigorously correct, those characterizations would have to include many qualifiers. Nevertheless, the picture of dissimilarity (and therefore potential supplementation) that they present is essentially valid. Computing machines can do readily, well, and rapidly many things that are difficult or impossible for man, and men can do readily and well, though not rapidly, many things that are difücult or impossible for computers. That suggests that a symbiotic cooperation, if successful in integrating the positive characteristics of men and computers, would be of great valué. The differences in speed and in language, of course, pose difficulties that must be overeóme.

4 separable functions of men and computers in the anticipated symbiotic association

It seems likely that the contributions of human operators and equipment will blend together so completely in many operations that it will be diíficult to sepárate them neatly in analysis. That would be the case if, in gathering data on which to base a decisión, for example, both the man and the computer carne up with rel-evant precedents from experience and if the computer then suggested a course of action that agreed with the man's intuitive judgment. (In theorem-proving programs, computers fmd precedents in experience, and in the SAGE System, they suggest courses of action. The foregoing is not a far-fetched example.) In other operations, however, the contributions of men and equipment will be to some extent separable.

Men will set the goals and supply the motivations, of course, at least in the early years. They will formúlate hypotheses. They will ask questions. They will think of mechanisms, procedures, and models. They will remember that such-and-such a person did some possibly relevant work on a topic of interest back in 1947, or at any rate shortly after World War II, and they will have an idea in what journals it might have been published. In general, they will make approximate and fallible, but leading, contributions, and they will define criteria and serve as evaluators, judging the contributions of the equipment and guiding the general lineofthought.

In addition, men will handle the very-low-probability situations when such situations do actually arise. (In current man-machine systems, that is one of the human operator's most important functions. The sum of the probabilities of very-low-probability alternatives is often much too large to neglect.) Men will ful in the gaps, either in the problem solution or in the computer program, when the computer has no mode or routine that is applicable in a particular circumstance.

The information-processing equipment, for its part, will convert hypotheses into testable models and then test the models against data (which the human operator may desígnate roughly and identify as relevant when the computer presents them for his approval). The equipment will answer questions. It will simúlate the mechanisms and models, carry out the procedures, and display the results to the operator. It will transform data, plot graphs ("cutting the caite" in whatever way the human operator specifies, or in several alternative ways if the human operator is not sure what he wants). The equipment will interpólate, extrapólate, and transíbrm. It *will* convert static equations or logical statements into dynamic models so the human operator can examine their behavior. In general, it will carry out the routinizable, clerical operations that fill the intervals be-tween decisions.

In addition, the computer will serve as a statistical-inference, decision-theory, or game-theoiy machine to make elementary evaluations of suggested courses ofaction whenever there is enough basis to support a formal statistical analysis. Fi-nally, it will do as much diagnosis, pattern-matching, and relevance-recognizingas it profitably can, but it will accept a clearly secondary status in those áreas

9

Douglas Engelbart

"Augmenting Human Intellect: A Conceptual Framework" (1962)

Douglas Engelbart at the Augmentation Research Center. Courtesy of Douglas Engelbart, Bootstrap Institute.

"The term '¡ntelligence amplificación' seems applicable to our goal ofaugmenting the human ¡ntellect ¡n that the entíty to be produced will exhlbít more of what can be calleó intelHgence than an unaided human could; we will have amplified the intelHgence ofthe human by organizing hls intelectual capabilitles into higher levéis of synergistic structuríng."

« Douglas Engelbart ¡s one of the most influential thinkers ¡n the history of personal computing. He is best known as the groundbreaking engineer who invented such mainstays of the personal computer as the mouse, Windows, email, and the word processor. He has received less recognition for his pioneering con-cepts behind the interactive computer networks that are the basis for the Internet. Engelbart led one of the most ¡mportant projects funded by ARPA in the 1960s: a networked environment designed to support collaborative interaction between people using computers. It was dubbed the oNLine System (NLS).This historie prototype, developed atthe Augmentaron Research Center of the Stan-ford Research Institute (SRI) and unveiled ¡n 1968 at the Fall Joint Computer Conference ¡n San Francisco, influenced the development of the first personal computer and the graphical user interface at Xerox PARC in the early 1970s.

Engelbart's experience as a radar specialist in wartime led him to consider the potential for a computer connected to a monitor display and an input device (such as a keyboard), which, ¡n the fifties and sixties, transformed the way people ¡nteracted with computers. In this paper, Engelbart describes in detail how such a computer might function—a description that predicts in remarkable detail the fundamental qualities of a modern personal computer. The linking of people and computers using this approach to interactivity would result ¡n the use of computers to "solve the world's problems," Engelbart wrote, by boosting the capacities of the mind's intellectual faculties.

Engelbart reasoned that networked computing would not only make individuáis more intellectually effective; it would enable a collaborative method of sharing knowledge. At the time, the ¡dea that computers could be operated intu-itively by teams engaged ¡n creative work was highly unorthodox. Engelbart pro-posed a language, process, methodology, and conceptual framework for the real-time interaction of collaborative computing. He was among the first to consider using computer networks to créate collective knowledge bases among groups of professionals.This approach has since transformed many of our insti-tutions, including the military, universities, museums, and librarles, as they have extended their reach into cyberspace. Engelbart's theories about the power of collective knowledge via a real-time electronic médium have also led to other forms of many-to-many human-computer interaction, including such collective online activities as virtual communities, on-line forums, and teleconferencing. »

I. introduction

A. General

By "augmenting human intellect" we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems. Increased capability in this re-spect is taken to mean a mixture of the following: more-rapid comprehension. better comprehension, the possibility of gaining a useful degree of comprehension in a situation that previously was too complex, speedier solutions, better solutions, and the possibility of finding solutions to problems that before seemed insoluble. And by "complex situations" we include the professional problems of diplomats, executives, social scientists, life scientists, physical scientists, attor-neys, designers—whether the problem situation exists for twenty minutes or twenty years. We do not speak of isolated clever tricks that help in particular situations. We refer to a way of life in an integrated domain where hunches, cut-and-try, intangibles, and the human "feel for a situation" usefully co-exist with powerful concepts, streamlined terminology and notation, sophisticated meth-ods, and high-powered electronic aids.

Man's population and gross product are increasing at a considerable rate, but the *complexity* of his problems grows still faster, and the *urgency* with which solutions must be found becomes steadily greater in response to the increased rate of activity and the increasingly global nature of that activity. Augmenting man's intellect, in the sense defined above, would warrant full pursuit by an enlightened society if there could be shown a reasonable approach and some plausible ben-efits.

This report covers the first phase of a program aimed at developing means to augment the human intellect. These "means" can include many things—all of which appear to be but extensions of means developed and used in the past to help man apply his native sensory, mental, and motor capabilities—and we con-sider the whole system of a human and his augmentation means as a proper field of search for practical possibilities. It is a very important system to our society. and like most systems its performance can best be improved by considering the whole as a set of interacting components rather than by considering the compo-nents in isolation.

This kind of system approach to human intellectual effectiveness does not find *a* ready-made conceptual framework such as exists for established disciplines. Befo re a research program can be designed to pursue such an approach intelligently, so that practical benefits might be derived within a reasonable time while also producing results of long-range significance, a conceptual framework must be searched out—a framework that provides orientation as to the important factors of the system, the relationships among these factors, the types of change among the system factors that offer likely improvements in performance, and the sort of research goals and methodology that seem promising.[1]

In the first (search) phase of our program we have developed a conceptual framework that seems satisfactory for the current needs of designing a research phase. Section II contains the essence of this framework as derived from several different ways of looking at the system made up of a human and his intellect-augmentation means.

The process of developing this conceptual framework brought out a number of significan! realizations: that the intellectual effectiveness exercised today by a given human has little likelihood of being intelligence limited—that there are dozens of disciplines in engineering, mathematics, and the social, life, and physical sciences that can contribute improvements to the system of intellect-augmentation means; that any one such improvement can be expected to trigger a chain of coordinating improvements; that until every one of these disciplines comes to a standstill *and* we have exhausted all the improvement possibilities we could glean from it, we can expect to continué to develop improvements in this "human-intellect" system; that there is no particular reason not to expect gains in personal intellectual effectiveness from a concerted system-oriented approach that compare to those made in personal geographic mobility since horseback and sailboat days....

To give the reader an initial orientation about what sort of thing this computer-aided working system might be, we include below a short description of a possible system of this sort. This illustrative example is not to be considered a description of the actual system that will emerge from the program. It is given only to show the general direction of the work, and is clothed in fiction only to make it easier to visualiza.

Let us consider an "augmented" architect at work. He sits at a working station that has a visual display screen some three feet on a side; this is his working surface, and is controlled by a computer (his "clerk") with which he can communicate by means of a small keyboard and various other devices.

He is designing a building. He has already dreamed up several basic layouts and structural forms, and is trying them out on the screen. The surveying data for the layout he *is* working on now have already been entered, and he has just coaxed the "clerk" to show him a perspective view of the steep hillside building site with the roadway above, symbolic representations of the various trees that are to remain on the lot, and the service tie points for the different Utilities. The view occupies the left two-thirds of the screen. With a "pointer," he indicates two points of interest, moves his left hand rapidly over the keyboard, and the distance and elevation between the points indicated appear on the right-hand third of the screen.

Now he enters a reference line with his "pointer" and the keyboard. Gradually the screen begins to show the work he is doing—a neat excavation appears in the hillside, revises itself slightly, and revises itself again. After a moment, the architect changes the scene on the screen to an overhead plan view of the site, still showing the excavation. A few minutes of study, and he enters on the keyboard a list of items, checking each one as it appears on the screen, to be studied later.

Ignoring the representation on the display, the architect next begins to enter a series of specifications and data—a six-inch slab floor, twelve-inch concrete walls eight feet high within the excavation, and so on. When he has finished, the revised scene appears on the screen. A structure is taking shape. He examines it, adjusts it, pauses long enough to ask for handbook or catalog information from the "clerk" at various points, and readjusts accordingly. He often recalls from the "clerk" his working lists of specifications and considerations to refer to them, modify them, or add to them. These lists grow into an ever-more-detailed, interlinked structure, which represents the maturing thought behind the actual design.

Prescribing different planes here and there, curved surfaces occasionally, and moving the whole structure about five feet, he finally has the rough external form of the building balanced nicely with the setting and he is assured that this form is basically compatible with the materials to be used as well as with the function of the building.

Now he begins to enter detailed information about the interior. Here the ca-pability of the "clerk" to show him any view he wants to examine (a slice of the interior, or how the structure would look from the roadway above) is important. He enters particular fixture designs, and examines them iri a particular room. He checks to make sure that sun glare from the windows will not blind a driver on the roadway, and the "clerk" computes the information that one window will re-flect strongly onto the roadway between 6 and 6:30 on midsummer mornings.

Next he begins a functional analysis. He has a list of the people who will oc-cupy this building, and the daily sequences of their activities. The "clerk" allows him to follow each in turn, examining how doors swing, where special lighting might be needed. Finally he has the "clerk" combine all of these sequences of activity to indícate spots where traffic is heavy in the building, or where congestión might occur, and to determine what the severest drain on the Utilities is likely to be.

All of this information (the building design and its associated "thought structure") can be stored on a tape to represent the "design manual" for the building. Loading this tape into his own "clerk," another architect, a builder, or the client can maneuver within diis "design manual" to pursue whatever details or insights are of interest to him—and can append special notes that are integrated into the "design manual" for his own or someone else's later benefit.

In such a future working relationship between human problem-solver and computer "clerk," the capability of the computer for executing mathematical processes would be used whenever it was needed. However, the computer has many other capabilities for manipulating and displaying information that can be of significant benefit to the human in nonmathematical processes of planning, organizing, studying, etc. Every person who does his thinking with symbolized concepts (whether in the form of the English language, pictographs, formal logic, or mathematics) should be able to benefit significandy.

B. Objedive ofthe Study

The objective of this study is to develop a conceptual framework within which could grow a coordinated research and development program whose goals would be the following: (1) to find the factors that limit the eñectiveness ofthe individual^ basic information-handling capabilities in meeting the various needs of so-ciety for problem solving in its most general sense; and (2) to develop new techm'ques, procedures, and systems that will better match these basic capabilities to the needs, problems, and progress of society. We have placed the following specifications on this framework:

3. That itprovideperspective for both long-range basic research and researchthat will yield practical results soon.
4. That it indicate what this augmentation will actually involve in the way of changes in working environment, in thinking, in skills, and in methods of working.

That it be a basis for evaluating the possible relevance of work and knowl-edge from existing fields and for assimilating whatever is relevant.

4. That it reveal áreas where research is possible and ways to assess the research, be a basis for choosing starting points, and indicate how to develop appropriate methodologies for the needed research.

Two points need emphasis here. First, although a conceptual framework has been constructed, it is still rudimentary. Further search, and actual research, are needed for the evolution of the framework. Second, even if our conceptual framework did provide an accurate and complete basic analysis of the system from which stems a human's intellectual efFectiveness, the explicit nature of future im-proved systems would be highly affected by (expected) changes in our technol-ogy or in our understanding of the human being.

II. conceptual framework

A. General

The conceptual framework we seek must orient us toward the real possibilities and problems associated with using modern technology to give direct aid to an individual in comprehending complex situations, isolating the significant fac-tors, and solving problems. To gain this orientation, we examine how individuáis achieve their present level of efFectiveness, and expect that this examination will reveal possibilities for improvement.

The entire effect of an individual on the world stems essentially from what he can transmit to the world through his limited motor channels. This in turn is based on inFormation received From the outside world through limited sensory channels; on information, drives, and needs generated within him; and on his processing of that information. His processing is of two kinds: that which he is generally conscious of (recognizing patterns, remembering, visualizing, abstracting, deducing, inducing, etc.), and that involving the unconscious processing and mediating of received and self-generated information, and the unconscious mediating of conscious processing itself.

The individual does not use this information and this processing to grapple directly with the sort of complex situation in which we seek to give him help. He uses his innate capabilities in a rather more indirect fashion, since the situation is generally too complex to yield directly to his motor actions, and always too complex to yield comprehensions and solutions from direct sensory inspection and use of basic cognitive capabilities. For instance, an aborigine who possesses all of our *basic* sensory-mental-motor capabilities, but does not possess our back-ground of indirect knowledge and procedure, cannot organiza the proper direct actions necessary to drive a car through traffic, request a book from the library, cali a committee meeting to discuss a tentative plan, cali someone on the tele-phone, or compose a letter on the typewriter.

Our culture has evolved means for us to organize the little things we can do with our basic capabilities so that we can derive comprehension from truly complex situations, and accomplish the processes of deriving and imple-menting problem solutions. The ways in which human capabilities are thus extended are here called *augmentation means,* and we define four basic classes of them:

10. *Artifacts*—physical objects designed to provide for human comfort, for themanipulation of things or materials, and for the manipulation of symbols.
11. *Language*—the way in which the individual pareéis out the picture of hisworld into the concepts that his mind uses to model that world, and thesymbols that he attaches to those concepts and uses in consciously ma-nipulating the concepts ("thinking").
12. *Methodology*—the methods, procedures, strategies, etc., with which an individual organizes his *goal-centered* (problem-solving) activity.
13. *Training*—the conditioning needed by the human being to bring his skills in using Means 1,2, and 3 to the point where they are operationally effective.

The system we want to improve can thus be visualized as a trained human being together with his artifacts, language, and methodology. The explicit new system we contémplate will involve as artifacts computers, and computer-controlled information-storage, information-handling, and information-display devices. The aspects of the conceptual framework that are discussed here are primarily those relating to the human being's ability to make signiíicant use of such equip-ment in an integrated system.

Pervading all of the augmentation means is a particular structure or organ-ization. While an untrained aborigine cannot drive a car through trafile, be-cause he cannot leap the gap between his cultural background and the kind of world that contains cars and trafEc, it is possible to move step by step through an organized training program that will enable him to drive effectively and safely. In other words, the human mind neither learns ñor acts by large leaps, but by steps organized or structured so that each one depends upon previous

stcpa.

Although the *size* of the step a human being can take in comprehension, innovation, or execution is small in comparison to the over-all size of the step needed to solve a complex problem, human beings nevertheless do solve complex problems. It is the augmentation means that serve to break down a large problem in such a way that the human being can walk through it with his little steps, and it is the structure or organization of these little steps or actions that we discuss as *process hierarchies.*

Every process of thought or action is made up of sub-processes. Let us consider such examples as making a pencil stroke, writing a letter of the alphabet, or making a plan. Quite a few discrete muscle movements are organized into the making of a pencil stroke; similarly, making particular pencil strokes and making a plan for a letter are complex processes in themselves that become sub-processes to the over-all writing oían alphabetic character.

Although every sub-process is a process in its own right, in that it consists of further sub-processes, there seems to be no point here in looking for the ultímate "bottom" of the process-hierarchical structure. There seems to be no way of telling whether or not the apparent "bottoms" (processes that cannot be further subdivided) exist in the physical world or in the limitations of human understanding.

In any case, it is not necessary to begin from the "bottom" in discussing particular process hierarchies. No person uses a process that is completely unique every time he tackles something new. Instead, he begins from a group of basic sensory-mental-motor process capabilities, and adds to these certain of the process capabilities of his artifacts. There are only a finite number of such basic human and artifact capabilities from which to draw. Furthermore, even quite different higher-order processes may have in common relatively high-order sub-processes.

When a man writes prose text (a reasonably high-order process), he makes use of many processes as sub-processes that are common to other high-order processes. For example, he makes use of planning, composing, dictating. The process of writing is utilized as a sub-process within many different processes of a still higher order, such as organizing a committee, changing a policy, and so on.

What happens, then, is that each individual develops a certain repertoire of process capabilities from which he selects and adapts those that will compose the processes that he executes. This repertoire is like a tool kit, and just as the mechanic must know what his tools can do and how to use them, so the intellectual worker must know the capabilities of his tools and have good methods, strategies, and rules of thumb for making use of them. All of the process capabilities in the individual's repertoire rest ultimately upon basic capabilities within him or his artifacts, and the entire repertoire represents an inter-knit, hierarchical structure (which we often cali the *repertoire hierarchy).*

We find three general categories of process capabilities within a typical individual's repertoire. There are those that are executed completely within the human integument, which we cali *explicit-human* process capabilities; there are those possessed by artifacts for executing processes without human interven-tion, which we cali *explicit-artifact* process capabilities; and there are what we cali the *composite* process capabilities, which are derived from hierarchies con-taining both of the other kinds.

We assume that it is our H-LAM/T system (Human using Language, Artifacts, Methodology, in which he is Trained) that has the capability and that per-forms the process in any instance of use of this repertoire. Let us look within the process structure for the LAM/T ingredients, to get a better "feel" for our models. Consider the process of writing an important memo. There is a particular concept associated with this process — that of putting information into a formal package and distributing it to a set of people for a certain kind of considera-tion— and the type of information package associated with this concept has been given the special ñame *of memorándum.* Already the system language shows the effect of this process— i.e., a concept and its ñame.

The memo-writing process may be executed by using a set of process capabilities (in intermixed or repetitive form) such as the following: planning, devel-oping subject matter, composing text, producing hard copy, and distributing. There is a definite way in which these sub-processes will be organized that represents part of the system methodology. Each of these sub-processes represents a functional concept that must be a part of the system language if it is to be organized eífectively into the human's way of doing things, and the symbolic por-

t&ra} ofeach coxcqvt jnust be such Óiat the human can work with it and rememher it.

If the memo is simple, a paragraph or so in length, then the first three processes may well be of the explicit-human type (i.e., it may be planned, devel-oped, and composed within the mind) and the last two of the composite type. If it is a complex memo, involving a good deal of careful planning and development, then all of the sub-processes might well be of the composite type (e.g., at least in-cluding die use oí pendí and paper artifacts), and diere migrtbe many dtfferent applications of some of the process capabüiües within the total process (i.e.,
successwe,

occasion and sequence, would indeed enable the execution of the memo-writing process. However, the very process of organizing and supervising the utilization of these sub-process capabilities is itself a most importan! sub-process of the memo-writing process. Henee, the sub-process capabilities as listed would not be complete without the addition of a seventh capability—what we cali the *exec-utive* capability. This is the capability stemming from habit, strategy, rules of thumb, prejudice, learned method, intuition, unconscious dictates, or combina-tions thereof, to cali upon the appropriate sub-process capabilities with a particular sequence and timing. An executive process (i.e., the exercise of an executive capability) involves such sub-processes as planning, selecting, and supervising, and it is really the executive processes that embody all of the method-ology in the H-LAM/T system.

To illustrate the capability-hierarchy features of our conceptual framework, let us consider an artifact innovation appearing directly within the relatively low-order capability for composing and modifying written text, and see how this can affect a (or, for instance, your) hierarchy of capabilities. Suppose you had a new wridng machine—think of it as a high-speed electric typewriter with some spe-cial features. You could opérate its keyboard to cause it to write text much as you could use a conventional typewriter. But the printing mechanism is more com-plicated; besides printing a visible character at every stroke, it adds special en-coding features by means of invisible selective components in the ink and special shaping of the character.

As an auxiliary device, there is a gadget that is held like a pencil and, instead of a point, has a special sensing mechanism that you can pass over a line of the special printing from your wridng machine (or one like it). The signáis which this reading stylus sends through the flexible connecdng wire to the writing machine are used to determine which characters are being sensed and thus to cause the automatic typing of a duplícate string of characters. An information-storage mechanism in the writing machine permits you to sweep the reading stylus over the characters much faster than the writer can type; the writer will catch up with you when you stop to think about what word or string of words should be du-plicated next, or while you reposition die straight-edge guide along which you run the stylus.

This writing machine would permit you to use a new process of composing text. For instance, trial drafts could rapidly be composed from re-arranged excerpts of oíd drafts, togedier with new words or passages which you stop to type in. Your first draft could represent a free outpouring of thoughts in any order, with the inspection of foregoing thoughts continuously stimulating new considerations and ideas to be entered. If the tangle of thoughts represented by the draft became too complex, you would compile a reordered draft quickly. It would be practical for you to accommodate more complexity in the trails of thought you might build in search of the path that suits your needs.

You can intégrate your new ideas more easily, and thus harness your creativ-ity more continuously, if you can quickly and flexibly change your working record. If it is easier to update any part of your working record to accommodate new developments in thought or circumstance, you will find it easier to incorpórate more complex procedures in your way of doing things. This will proba-bly allow you to accommodate the extra burden associated with, for instance, keeping and using special files whose contents are both contributed to and uti-lized by any current work in a flexible manner—which in turn enables you to devise and use even-more-complex procedures to better harness your talents in your particular working situation.

The important thing to appreciate here is that a direct new innovation in one particular capability can have far-reaching effects throughout the rest of your capability hierarchy. A change can propágate *up* through the capability hierarchy; higher-order capabilities that can utilize the initially changed capability can now reorganize to take special advantage of this change and of the intermediate higher-capability changes. A change can propágate *down* through the hierarchy as a result of new capabilities at the high level and modification possibilities la-tent in lower levéis. These latent capabilities may previously have been unusable in the hierarchy and become usable because of the new capability at the higher level.

The writing machine and its flexible copying capability would occupy you for a long time if you tried to exhaust the reverberating chain of associated possibilities for making useful innovations within your capability hierarchy. This one innovation could trigger a rather extensive redesign of this hierarchy; your way oí accomplishing many of your tasks would change considerably. Indeed, this process characterizes the sort of evolution that our intellect-augmentation means have been undergoing since the first human brain appeared.

To our objective of deriving orientation about possibilities for actively pursuing an increase in human intellectual eífectiveness, it is important to realize that we must be prepared to pursue such new-possibility chains throughout the *en-tire* capability hierarchy (calling for a "system" approach). It is also important te realize that we must be oriented to the *synthesis* of new capabilities from reorga-nization of other capabilities, both oíd and new, that exist throughout the hierarchy (calling for a "system-engineering" approach).

Individuáis who opérate effectively in our culture have already been considerably "augmented." Basic human capabilities íbr sensing stimuli, performing numer-ous mental operations, and for communicating with the outside world, are put to work in our society within a system—an H-LAM/T system—the individual augmented by the language, artifacts, and methodology in which he is trained. Fur-thermore, we suspect that improving the effectiveness of the individual as he opérales in our society should be approached as a system-engineering prob-lem—that is, the H-LAM/T system should be studied as an interacting whole from a synthesis-oriented approach.

This view of the system as an interacting whole is strongly bolstered by considering the repertoire hierarchy of process capabilities that is structured from the basic ingredients within the H-LAM/T system. The realization that any potencial change in language, artifact, or methodology has importance only relative to its use within a process, and that a new process capability appearing anywhere within that hierarchy can make practical a new consideration of latent change possibilities in many other parts of the hierarchy—possibilities in either language, artifacts, or methodology—brings out the strong interrelationship of these three augmentation means.

Increasing the effectiveness of the individual's use of his basic capabilities is a problem in redesigning the changeable parts of a system. The system is actively engaged in the continuous processes (among others) of developing comprehen-sion within the individual and of solving problems; both processes are subject to human motivation, purpose, and will. To redesign the system's capability for performing these processes means redesigning all or part of the repertoire hierarchy. To redesign a structure, we must learn as much as we can of what is known about the basic materials and components as they are utilized within the structure; beyond that, we must learn how to view, to measure, to analyze, and to evalúate in terms of the functional whole and its purpose. In this particular case, no existing analytic theory is by itself adequate for the purpose of analyzing and evaluating over-all system performance; pursuit oían improved system thus de-mands the use *oí experimental* methods.

It need not be just the very sophisticated or formal process capabilities that are added or modified in this redesign. Essentially any of the processes utilized by a representative human today—the processes that he thinks of when he lookí ahead to his day's work—are composite processes of the sort that involve exter nal composing and manipulating of symbols (text, sketches, diagrams,lists, etc.)

Many of the external composing and manipulating (modifying, rearranging) processes serve such characteristically "human" activities as playing with forms and relationships to see what develops, cut-and-try multiple-pass development of an idea, or listing Ítems to reflect on and then rearranging and extending them as thoughts develop.

Existing, or near-future, technology could certainly provide our professional problem-solvers with the artifacts they need to have for duplicating and rearranging text before their eyes, quickly and with a minimum of human effort. Even so apparently minor an advance could yield total changes in an individual's repertoire hierarchy that would represent a great increase in over-all effectiveness. Normally the necessary equipment would enter the market slowly; changes from the expected would be small, people would change their ways of doing things a little at a time, and only gradually would their accumulated changes créate mar-kets for more radical versions of the equipment. Such an evolutionary process has been typical of the way our repertoire hierarchies have grown and formed.

But an active research effort. aimed at exploring and evaluating possible integrated changes throughout the repertoire hierarchy, could greatly accelerate this evolutionary process. The research effort could guide the product development of new artifacts toward taking long-range meaningful steps; simultaneously, com-petitively minded individuáis who would respond to demonstrated methods for achieving greater personal effectiveness would créate a market for the more radical equipment innovations. The guided evolutionary process could be expected to be considerably more rapid than the traditional one.

The category of "more radical innovations" includes the digital computer as a tool for the personal use of an individual. Here there is not only promise of great flexibility in the composing and rearranging of text and diagrams before the individual's eyes, but also promise of many other process capabilities that can be integrated into the H-LAM/T system's repertoire hierarchy.

*C. Detailed Discussion ofthe H-LAM/T System*1. the source of intelligence When one looks at a computer system that is doing a very complex job, he sees on the surface a machine that can exe-cute some extremely sophisticated processes. If he is a layman, his concept oi what provides this sophisticated capability may endow the machine with a mys-terious power to sweep information through perceptive and intelligent synthetic thinking devices. Actually, this sophisticated capability results from a very cleveí arganizational hierarchy, so that pursuit of the source of intelligence within this system would take one down through layers of functional and physical organization that become successively more primitive.

To be more specific, we can begin at the top and list the major levéis down through which we would pass if we successively decomposed the functional el-ements of each level, in search of the "source of intelligence." A programmer could take us down through perhaps three levéis (depending upon the sophisti-cation of the total process being executed by the computer) perhaps depicting the organization at each level with a flow chart. The first level down would organize functions corresponding to statements in a problem-oriented language (e.g.. ALGOL or COBOL), to achieve the desired over-all process. The second level down would organize lesser functions into the processes represented by first-level statements. The third level would perhaps show how the basic machine com-mands (or rather the processes which they represent) were organized to achieve each of the functions of the second level.

Then a machine designer could take over, and with a block diagram of the computer's organization he could show us (Level 4) how the different hardware units (e.g., random-access storage, arithmetic registers, adder, arithmetic control) are organized to provide the capability of executing sequences of the commands used in Level 3. The logic designer could then give us a tour of Level 5, also using block diagrams, to show us how such hardware elements as pulse gates, flip-flops, and AND, OR, and NOT circuits can be organized into networks giving the functions utilized at Level 4. For Level 6 a circuit engineer could show us diagrams revealing how components such as transistors, resistors, capacitors, and diodes can be organized into modular networks that provide the functions needed for the elements of Level 5.

Device engineers and physicists of different kinds could take us down through more layers. But rather soon we have crossed the boundary between what is man-organized and what is nature-organized, and are ultimately dis-cussing the way in which a given physical phenomenon is derived from the in-trinsic organization of sub-atomic particles, with our ability to explain succeeding layers blocked by the exhaustion of our present human comprehension.

If we then ask ourselves where that intelligence is embodied, we are forced to concede that it is elusively distributed throughout a hierarchy of functional processes—a hierarchy whose foundation extends down into natural processes below the depth of our comprehension. If there is any one thing upon which this "intelligence" depends, it would seem to be *organization,* The biologists and ohvsiolodsts use a term "synergism" to desígnate (from *Webster's Unabridged Dictionary,* Second Edition) the "... cooperative action of discrete agencies such that the total effect is greater than the sum of the two effects taken indepen-dendy..." This tenn seems directly applicable here, where we could say that syn-ergism is our most likely candidate for representing the actual source of intelligence.

Actually, each of the social, life, or physical phenomena we observe about us would seem to derive from a supporting hierarchy of organized functions (or processes), in which the synergistic principie gives increased phenomenological sophistication to each succeedingly higher level of organization. In particular, the intelligence of a human being, derived ultimately from the characteristics of individual nerve cells, undoubtedly results from synergism.

2. intelligence amplification It has been jokingly suggested several times during the course of this study that what we are seeking is an "intelligence amplifier." (The term is attributed originally to W. Ross Ashby.[2] At first this temí was rejected on the grounds that in our view one's only hope was to make a bet-ter match between existing human intelligence and the problems to be tackled, rather than in making man more intelligent. But deriving the concepts brought out in the preceding section has shown us that indeed this term does seem applicable to our objective.)

Accepting the term "intelligence amplification" does not imply any attempt to increase native human intelligence. The term "intelligence amplification" seems applicable to our goal of augmenting the human intellect in that the entity to be produced will exhibit more of what can be called intelligence than an unaided human could; we will have amplified the intelligence of the human by organizing his intellectual capabilities into higher levéis of synergistic structuring. What pos-sesses the amplified intelligence is the resulting H-LAM/T system, in which the LAM/T augmentation means represent the amplifier of die human's intelligence.

In amplifying our intelligence, we are applying the principie of synergistic structuring that was followed by natural evolution in developing the basic human :apabilities. What we have done in the development of our augmentation means s to construct a superstructure that is a synthetic extensión of the natural struc-:ure upon which it is built. In a very real sense, as represented by the steady evo-ution of our augmentation means, the development of "artificial intelligence" has)een going on for centuries.

5. Two-DoMAiN system The human and the artifacts are the only physical •omnonents in the H-LAM/T svstem. It is upon their capabilities that the ulti-

mate capability of the system will depend. This was implied in the earlier statement that every composite process of the system decomposes ultimately inte explicit-human and explicit-artifact processes. There are thus two sepárate domains of activity within the H-LAM/T system: that represented by the human, in which all explicit-human processes occur; and that represented by the artifacts in which all explicit-artifact processes occur. In any composite process, there is cooperative interaction between the two domains, requiring interchange of en-ergy (much of it for information exchange purposes only). Figure 1 depicts this two domain concept and embodies other concepts discussed below.

Outside World

H-LAM/T System

Matching Processes

Energy Flow

Matching Processes

Human Processes

Man-Artifact-Interface

Artifact Processes

FIGURE 1. *Portrayal ofthe Tino Actove Domains within the H-LMA/TSystem.*

Where a complex machine represents the principal artifact with which a liuman being cooperates, the term "man-machine interface" has been used for sorne years to represent the boundary across which energy is exchanged between the two domains. However, the "man-artifact interface" has existed for centuries. sver since humans began using artifacts and executing composite processes.

Exchange across this "interface" occurs when an explicit-human process is coupled to an explicit-artifact process. Quite often these coupled processes are designed for just this exchange puipose, to provide a functional match between other explicit-human and explicit-artifact processes buried within their respective domains that do the more significant things. For instance, the finger and hand motions (explicit-human processes) actívate key-linkage motions in the typewriter (couple to explicit-artifact processes). But these are only part ofthe matching processes between the deeper human processes that direct a given word to be typed and the deeper artifact processes that actually imprint the ink marks on the naner.

The outside world interacts with our H-LAM/T system by the exchange of snergy with either the individual or his artifact. Again, special processes are often designed to accommodate this exchange. However, the direct concern of our present study lies within the system, with the internal processes that are and can be significantly involved in the effectiveness of the *system* in developing the human's comprehension and pursuing the human's goals....

5. capability repertoire hierarchy The concept of our H-LAM/T system possessing a repertoire of capabilities that is structured in the form of a lierarchy is most useful in our study. We shall use it in the following to tie torether a number of considerations and concepts.

There are two points of focus in considering the design of new repertoire hi-;rarchies: the materials with which we have to work, and the principies by which lew capability is constructed from these basic materials.

i. Basic Capabilities

Materials in this context are those capabilities in the human and in the artifact do-nains from which all other capabilities in the repertoire hierarchy must be con-¡tructed. Each such basic capability represents a type of functional component vith which the system can be built, and a thorough Job of redesigning the system :alls for making an inventory of the basic capabilities available. Because we are -.xploring for perspective, and not yet recommending research activities, we are ree to discuss and define in more detail what we mean by "basic capability" vithout regard to the amount of research involved in making an actual inventory. The two domains, human and artifact, can be explored separately for their >asic capabilities. In each we can isolate two classes of basic capability; these lasses are distinguished according to whether or not the capability has been >ut to use within out augmentation means. The first class (those in use) can be ound in a methodical manner by analyzing present capability hierarchies. For ex-mple, select a given capability, at any level in the hierarchy, and ask yourself if it an be usefully changed by any means that can be given consideration in the ugmentation research contemplated. If it can, then it is not basic but it can be iecomposed into an eventual set of basic capabilities. As you proceed down lirough the hierarchy, you will begin to encounter capabilities that cannot be useally changed, and these will make up your inventory of basic capabilities. Ultilately, every such recursive decomposition of a given capability in the hierarchy rill find everv one of its branchine paths terminated by basic capabilities. Be- such decomposition search with different capabilities in the hierarchy will eventually uncover all of those basic capabilities used within that hierarchy or augmentation system. Many of the branching paths in the decomposition of a given higher-order capability will terminate in the same basic capability, since a given basic capability will often be used within many different higher-order capabilities.

Determining the class of basic capabilities not already utilized within existing augmentation systems requires a different exploration method. Examples of this method occur in technological research, where analytically oriented re-searchers search for new understandings of phenomena that can add to the research engineer's list of things to be used in the synthesis of better artifacts.

Before this inventorying task can be pursued in any specific instance, some criteria must be established as to what possible changes within the H-LAM/T system can be given serious consideration. For instance, some research situa-tions might have to disallow changes which require extensive retraining, or which require undignified behavior by the human. Other situations might admit changes requiring years of special training, very expensive equipment, or the use ofspecialdrugs.

The capability for performing a certain finger action, for example, may not be basic in our sense of the word. Being able to extend the finger a certain distance would be basic, but the strength and speed of a particular finger motion and its coordination with higher actions generally are usefully changeable and there-fore do not represent basic capabilities. What would be basic in this case would perhaps be the processes whereby strength could be increased and coordinated movement patterns learned, as well as the basic movement range established by the mechanical-limit loci of the muscle-tendon-bone system. Similar capability breakdowns will occur for sensory and cognitive capabilities.

b. Structure Types

1) General The fundamental principie used in building sophisticated capabilities from the basic capabilities is structuring— the special type of structuring (which we have termed synergetic) in which the organization of a group of ele-ments produces an effect greater than the mere addiüon of their individual effects, Perhaps "purposeful" structuring (or organization) would serve us as well, bul since we aren't sure yet how the structuring concept must mature for our needs we shall tentatively stick with the special modiíier, "synergetic." We are devélenme a Erowine: awareness of the significan! and pervasive nature of such structure within every physical and conceptual thing we inspect, where the hierarchical form seems almost universally present as stemming from successive levéis of such organización.

The fundamental entities that are being structured in each and every case seems to be what we could cali processes, where the most basic of physical processes (involving fields, charges, and momenta associated with the dynamics of fundamental particles) appear to be the hierarchical base. There are dynamic electro-optical-mechanical processes associated with the function of our arti-facts, as well as metabolic, sensory, motor, and cognitive processes of the human, which we find to be relatively fundamental components within the structure oí our H-LAM/T system—and each of these seems truly to be ultimately based (to our degree of understanding) upon the above mentioned basic physical processes. The elements that are organized to give fixed structural form to our physical objects—e.g., the "element" of tensile strength of a material—are also de-rived from what we could cali synergetic structuring of the most basic physical processes.

But at the level of the capability hierarchy where we wish to work, it seems useful to us to distinguish several different types of structuring—even though each type is fundamentally a structuring of the basic physical processes. Tenta-tively we have isolated five such types—although we are not sure how many we shall ultimately want to use in considering the problem of augmenting the human intellect, ñor how we might divide and subdivide these different manifestations of physical-process structuring. We use the terms "mental structuring," "concept structuring," "symbol structuring," "process structuring," and "physical structuring."

2) Mental Structuring Mental structuring is what we cali the internal organization of conscious and unconscious mental images, associations, or concepts (or whatever it is that is organized within the human mind) that somehow manages to provide the human with understanding and the basis for such as judgment, in-tuition, inference, and meaningful action with respect to his environment. There is a term used in psychology, "cognitive structure," which so far seems to represen! just what we want for our concept of mental structure, but we will not adopt t until we become more sure of what the accepted psychological meaning is and jf what we want for our conceptual framework.

For our present purpose, it is irrelevant to worry over what the fundamenal mental "things" being structured are, or what mechanisms are accomplish-ng the structurine: or makine: use of what has been structured. We fppl reasonably safe in assuming that learning involves some kind of meaningful or-ganization within the brain, and that whatever is so organized or structured rep-resents the operating model of the individual's universe to the mental mechanisms that derive his behavior. And further, our assumption is that when the human in our H-LAM/T system makes the key decisión or action that leads to the solution of a complex problem, it will stem from the state of his mental structure at that time. In this view, then, the basic purpose of the sys-tem's activity on that problem up to that point has been to develop his mental structure to the state from which the mental mechanisms could derive the key action.

Our school systems attest that there are specific experiences that can be given to a human that will result in development of his mental structure to the point where the behavior derived therefrom by his mental mechanisms shows us that he has gained new comprehension—in other words, we can do a certain amount from outside the human toward developing his mental structure. Independent students and researchers also attest that internally directed behavior on the part of an individual can directly aid his structure-building process.

We don't know whether a mental structure is developed in a manner analo-gous to (a) development of a garden, where one provides a good environment, plants the seeds, keeps competing weeds and injurious pests out, but otherwise has to let natural processes take their course, or to (b) development of a basket-ball team, where much exercise of skills, patterns, and strategies must be provided so that natural processes can slowly knit together an integration, or to (c) development of a machine, where carefully formed elements are assembled in a precise, planned manner so that natural phenomena can immediately yield planned function. We don't know the processes, but we can and have developed empiri-cal relationships between the experiences given a human and the associated man-ifestations of developing comprehension and capability, and we see the near-future course of the research toward augmenting the human's intellect as de-pending entirely upon empirical findings (past and future) for the development of better means to serve the development and use of mental structuring in the human.

We don't mean to imply by this that we renounce theories of mental processes. What we mean to emphasize is that pursuit of our objective need nol wait upon the understanding of the mental processes that accomplish (what w£ cali) mental structuring and that derive behavior therefrom. It would be to ignor< the emphases of our own conceptual framework not to make fullest use of any the nrv that nrovided a working; explanation for a group of empirical data. What'i more, our entire conceptual framework represents the first pass at a "theoreticaP model with which to organize our thinking and action.

3) Concept Structuring Within our framework we have developed the working assumption that the manner in which we seem to be able to provide experiences that favor the development of our mental structures is based upon concepts as a "médium of exchange." We view a concept as a tool that can be grasped and used by the mental mechanisms, that can be composed, interpreted, and used by the natural mental substances and processes. The grasping and handling done by these mechanisms can often be facilitated if the concept is given an explicit "handle" in the form of a representative symbol. Somehow the mental mechanisms can learn to manipúlate images (or something) of symbols in a meaning-ful way and remain calmly confident that the associated conceptual manipulations are within cali.

Concepts seem to be structurable, ín that a new concept can be composed oí an organization of established concepts. For present purposes, we can view a *concept structure* as something which we might try to develop on paper for our-selves or work with by conscious thought processes, or as something which we try to communicate to one another in serious discussion. We assume that, for a jfiven unit of comprehension to be imparted, there is a concept structure (which :an be consciously developed and displayed) that can be presented to an individual in such a way that it is mapped into a corresponding mental structure tvhich provides the basis for that individual's "comprehending" behavior. Our >vorking assumption also considers that some concept structures would be bet-:er for this purpose than others, in that they would be more easily mapped by the ndividual into workable mental structures, or in that the resulting mental struc-:ures enable a higher degree of comprehension and better solutions to prob-ems, or both.

A concept structure often grows as part of a cultural evolution—either on a arge scale within a large segment of society, or on a small scale within the activ-ty domain of an individual. But it is also something that can be directly designed ir modified, and a basic hypothesis of our study is that better concept structures an be developed—structures that when mapped into a human's mental structure ¿11 significantly improve his capability to comprehend and to find solutions /ithin his complex-problem situations.

A natural language provides its user with a ready-made structure of concepts lat establishes a basic mental structure, and that allows relatively flexible, eneral-purpose concept structuring. Our concept of "lansoiase" as one of the

basic means for augmenting the human intellect embraces all of the concept structuring which the human may make use of.

4) Symbol Structuring The other important part of our "language" is the wav in which concepts are represented—the symbols and *symbol structures.* Words structured into phrases, sentences, paragraphs, monographs—charts, lists, diagrams, tables, etc. A given structure of concepts can be represented by any of ai. infinite number of difíerent symbol structures, some of which would be much better than others for enabling the human perceptual and cognitive apparatus k search out and comprehend the conceptual matter of significance and/or interest to the human. For instance, a concept structure involving many numérica! dau would generally be much better represented with Arabic rather than Román numeráis and quite likely a graphic structure would be better than a tabular structure.

But it is not only *the form* of a symbol structure that is important. A probleír solver is involved in a stream of conceptual activity whose course serves his mental needs of the moment. The sequence and nature of these needs are quite variable, and yet for each need he may benefit significantly from a form of symrx*'.* structuring that is uniquely efficient for that need.

Therefore, besides the forms of symbol structures that can be constructc^ and portrayed, we are very much concerned with the speed and flexibility **with** which one form can be transformed into another, and with which new mater.^ can be located and portrayed.

We are generally used to thinking of our symbol structures as a pattern marks on a sheet of paper. When we want a difíerent symbol-structure view. **we** thitik of shifting our point of attention on the sheet, or moving a new sheet into position. But another kind of view might be obtained by extracting and orden:.; all statements in the local text that bear upon Consideration A of the argument-or by replacing all occurrences of specified esoteric words by one's own def tions. This sort of "view generation" becomes quite feasible with computer-controlled display system, and represents a very significan! capabi to build upon.

With a computer manipulating our symbols and generating their portray; to us on a display, we no longer need think of our looking at *the* symbol struc which is stored—as we think of looking at *the* symbol structures stored in noi books, memos, and books. What the computer actually stores need be none our concern, assuming that it can portray symbol structures to us that aie sistent with the form in which we think our information is structured.

A given concept structure can be represented with a symbol structure that is :ompletely compatible with the computer's interna! way of handling symbols, ivith al! sorts of characteristics and relationships given explicit identifícations that the user may never directly see. In fact, this structuring has immensely greater potential for accurately mapping a complex concept structure than does a structure an individual would find it practical to construct or use on paper.

The computer can transform back and forth between the two-dimensional portrayal on the screen, of some limited view of the total structure, and the aspect of the n-dimensional interna! image that represents this "view." If the human adds to or modifíes such a "view," the computer integrales the change into the internal-image symbol structure (in terms of the computer's favored symbols and structuring) and thereby automatically detects a certain proportion of his possible conceptual inconsistencies.

Thus, inside íhis instrument (the computer) there is an internal-image, computer-symbol structure whose convolutions and multi-dimensionality we can learn to shape to represent to hitherto unattainable accuracy the concept structure we might be building or working with. This internal structure may have a form that is nearly incomprehensible to the direct inspection of a human (except in minute chunks).

But let the human specify to the instrument his particular conceptual need oi :he moment, relative to this internal image. Without disrupting its own internal "eference structure in the slightest, the computer will effectively stretch, bend. bld, extract, and cut as it may need in order to assemble an internal substructure :hat is its response, structured in its own internal way. With the set of standard ranslation rules appropriate to the situation, it portrays to the human via its dis-)lay a symbol structure designed for *his* quick and accurate perception and com->rehension of the conceptual matter pertinent to this internally composed ubstructure.

No longer does the human work on stiff and limited symbol structures, where nuch of the conceptual contení can only be implicitly designated in an indirect nd distributed fashion. These new ways of working are basically available with oday's technology—we have but to free ourselves from some of our limiting iews and begin experimenting with compatible sets of structure forras and irocesses for human concepts, human symbols, and machine symbols.

) Process Structuring Essentially everything that goes on within the H-LAM/T ystem and that is of direct interest here involves the manipulation of concept and vmhol stmrtures in serviré to the mental structure. Therefore. the orocesses within the H-LAM/T system that we are most interested in developing are those that provide for the manipulation of all three types of structure. This brings us to the fourth category of *structuring process* structuring.

As we are currently using it, the term *process structuring* includes the organization, study, modification, and execution of processes and process structures. Whereas concept structuring and symbol structuring together represent the lan-guage component of our augmentation means, process structuring represents the methodology component (plus a little more, actually). There has been enough previous discussion of process structures that we need not describe the notion here, beyond perhaps an example or two. The individual processes (or actions) of my hands and fingers have to be cooperatively organized if the typewriter is to do my bidding. My successive actions throughout my working day are meant to cooperate toward a certain over-all professional goal.

Many of the process structures are applied to the task of organizing, executing. supervising, and evaluating other process structures. Many of them are applied to the formation and manipulation of symbol structures (the purpose of which will often be to support the conceptual labor involved in process structuring).

6) Physical Structuring Physical structuring, the last of the five types which we currently use in our conceptual framework, is nearly self-explanatory. It pretty well represents the artifact component of our augmentation means, insofar as their actual physical construction is concerned....

e. Flexibility in the Executive Role

[T]here is finite human capability which must be divided between executive and direct-contributive activities [in the H-LAM/T system]. An important aspect of the multi-role activity of the human in the system is the development and manipulation of the symbol structures associated with *both* his direct-contributive roles and his executive roles.

When the system encounters a complex situation in which comprehension and problem solutions are being pursued, the direct-contributive roles re-quire the development of symbol structures that portray the concepts involved within the situation. But executive roles in a complex problem situation also re-quire conceptual activity—e.g., comprehension, selection, supervisión—that can benefit from well-designed symbol structures and fast, flexible means for manip-ulating and displaying them. For complex processes, the executive problem posed to the human íof eaining the necessary comprehension and making a good plan)

may be tougher than the problem he faced in the role of direct-contributive worker. If the flexibility desired for the process hierarchies (to make room for human cut-and-try methods) is not to be degraded or abandoned, the executive activity wiH have to be provided with fast and flexible symbol-structuring techniques.

The means available to humans today for developing and manipulating these symbol structures are both laborious and inflexible. It is hard enough to develop an initial structure of diagrams and text, but the amount of effort required to make changes is often prohibitively great; one settles for inflexibility. Also, the kind of generous flexibility that would be truly helpful calis for added symbol structuring just to keep track of the triáis, branches, and reasoning thereto that are involved in the development of the subject structure; our present symbol-manipulation means would very soon bog down completely among the com-plexities that are involved in being more than just a little bit flexible.

We find that the humans in our H-LAM/T systems are essentially working continuously within a symbol structure of some sort, shifting their attention from one structure to another as they guide and execute the processes that ultímately provide them with the comprehension and the problem solutions that they seek. This view increases our respect for the essential importance of the basic capa-bility of composing and modifying efEcient symbol structures. Such a capability depends heavily upon the particular concepts that are isolated and manipulated as entities, upon the symbology used to represent them, upon the artifacts that help to manipúlate and display the symbols, and upon the methodology for developing and using symbol structures. In other words, this capability depends heavily upon proper language, artifacts, and methodology, our basic augmenta-tion means.

When the course of action must respond to new comprehension, new insights and new intuitive flashes of possible explanations or solutions, it will not be an orderly process. Existing means of composing and working with symbolstructures penalize disorderly processes very heavily, and it is part of the realpromise in the automated H-LAM/T systems of tomorrow that the human canhave the freedom and power of disorderly processes

VI. CONCLUSIONS

Three principal conclusions may be drawn concerning the signíficance and im-plications of the ideas that have been presented.

First, any possibility for improving the effective utilization of the intellectual

power of society's problem solvers warrants the most serious consideration. This is because man's problem-solving capability represents possibly the most important resource possessed by a society. The other contenders for first impor-tance are all critically dependen! for their development and use upon this resource. Any possibility for evolving an art or science that can couple directly and significantly to the continued development of that resource should warrant doubly serious consideration.

Second, the ideas presented are to be considered in both of the above senses: the direct-development sense and the "art of development" sense. To be sure, the possibilities have long-term implications, but their pursuit and initial rewards await us now. By our view, we do not have to wait until we learn how the human mental processes work, we do not have to wait until we learn how to make com-puters more intelligent or bigger or faster; we can begin developing powerful and economically feasible augmentation systems on the basis of what we now know and have. Pursuit of further basic knowledge and improved machines will continué into the unlimited future, and will want to be integrated into the "art" and its improved augmentation systems—but getting started now will provide not only orientation and stimulation for these pursuits, but will give us improved problem-solving efFectiveness with which to carry out the pursuits.

Third, it becomes increasingly clear that there should be action now—the sooner the better—action in a number of research communities and on an ag-gressive scale. We oífer a conceptual framework and a plan for action, and we rec-ommend that these be considered carefully as a basis for action. If they be considered but found unacceptable, then at least serious and continued effort should be made toward developing a more acceptable conceptual framework within which to view the overall approach, toward developing a more acceptable plan of action, or both.

This is an open plea to researchers and to those who ultimately motivate, finance, or direct them, to turn serious attention toward the possibility of evolving a dynamic discipline that can treat the problem of improving intellectual efFectiveness in a total sense. This discipline should aim at producing a continuous cycle of improvements—increased understanding of the problem, improved means for developing new augmentation systems, and improved augmentation systems that can serve the world's problem solvers in general and this discipline'* workers in particular. After all, we spend great sums for disciplines aimed at understanding and harnessing nuclear power. Why not consider developing a discipline aimed at understanding and harnessing "neural power"? In the long run. the oower of the human intellect is reallv much the more important of the two.

jonn cage

"Diary: Audience 1966," *A Year From* A/oncfay (1966)

John Cage, Variations V. *Photo by Herve Gloaguen. Courtesy ofMerce Cunningham Dance Foundation.*

"What'll art become? A family reunión? Ifso, let's have ¡t wíth people in the round, each individual free to lend his attention whereverhe will."

« As a musician, composer, artist, poet, and philosopher, John Cage's work rarely fit within the traditional boundaries of artistic practice. Originally from Los Angeles, where he was a student of the Viennese composer Arnold Schoenberg, Cage's interdísciplinary ¡nterests led him far from the conventions of his musical training. In the late 1940s, during a residency at Black Mountain College, he developed his provocative "theater of mixed-means" in collaborations with the artists Robert Rauschenberg and Jasper Johns and the choreographer Merce Cunningham. These experiments gave birth to an explosión of performance art in the 1950s and 1960s that introduced al I types of actions, artifacts, noises, images, and movement into the performance space, which culminated in the Happenings.

Cage embraced ¡ndeterminacy as an integral part of his process of composition; this technique led him to ¡nclude the participation of the audience in the creation of his work. Inspired by Zen Buddhism, he reveled in an anarchy that dethrones the artist as the heroic, all-powerful arbiter of creative expression. He proposed instead a shift to an inclusive, participatory art that encourages interaction between artist, performer and audience, one in which the latter "can sit quietly or make noises ... whisper, talk and even shout/'This is best illustrated by his iñfamous piece from 1953, *4'33",* in which the pianist David Tudor remained silent at his instrument for the prescribed duration of time. While the piece was initially met by critics as a scandal, Cage's intent was to encourage the listener to contémplate the passing of time freely while listening attentively to the random sounds of the concert hall.

In this essay, Cage links the notion of an ¡nteractive listener to the concept of the computer as an agent of participation rather than as a servile, "labor-saving" device. His insightful analysis of the changing relationship between the artwork and the viewer has set the stage for much that has since become widespread in human-computer interaction, and has profoundly influenced later generations of media artists exploring interactive strategies. »

I. Are we an audience for computer art? The answer's not No; it's Yes. What we need is a computer that isn't labor-saving but which increases the work for us to do, that puns (this is McLuhan's idea) as well as Joyce revealing bridges (this is Brown's idea) where we thought there weren't any, turns us (my idea) not "on" but into artists. *Orthodox seatins; arransement in synasvs^ies.* Indians have known it for ages: life's a dance, a play, illusion. Lila. Maya. Twentieth-century art's opened our eyes. Now music's opened our ears. Theatre? Just notice what's iround. (If what you want in India is an audience, Gita Sarabhai told me, all you need is one or two people.) II. He said: Listening to your music I find it provokes me. What should I do to enjoy it? Answer: There're many ways to help you. I'd give you a lift, for instance, if you were going in my direction, but the last thing I'd do would be to tell you how to use your own aesthetic faculties. (You see? We're unemployed. If not yet, "soon again 'twill be." We have nothing to do. So what shall we do? Sit in an audience? Write criticism? Be creative?) We used to have the artist up on a pedestal. Now he's no more extraordinary than we are. III. Notice audiences at high altitudes and audiences in northern countries tend to be attentive during performances while audiences at sea level or in warm countries voice their feelings whenever they have them. Are we, so to speak, going south in the way we experience art? Audience participation? (Having nothing to do, we do it nonetheless; our biggest problem is finding scraps of time in which to get it done. Discovery. Awareness.) "Leave the beaten track. You'll see some-thing never seen before." *After thefirst performance ofmy piecefor twelve radios, Virgil Thomson said, "You can't do that sort of thing and expect people to payfor it." Separation.* IV. When our time was given to physical labor, we needed a stiff upper lip and backbone. Now that we're changing our minds, intent on things invisible, inaudible, we have other spineless virtues: flexibility, fluency. Dreams, daily events, everything gets to and through us. (Art, if you want a definition oí it, is criminal action. It conforms to no rules. Not even its own. Anyone who ex-periences a work of art is as guilty as the artist. It is not a question of sharing the guilt. Each one of us gets all of it.) They asked me about theatres in New York. I said we could use them. They should be small for the audiences, the performing áreas large and spacious, equipped for televisión broadcast for those who prefer staying at home. There should be a café in connection having food and drink, no music, facilities for playing chess. V. What happened at Rochester? We'd no sooner begun playing than the audience began. Began what? Costumes. Food. Rolls of toilet paper projected in streamers from the balcony through the air. Programs, too, folded, then flown. Music, perambulations, conversations. Began festivities. *An audience can sit quietly or make noises. People can whisper, talk and even shout. An audience can sit still or it can get up and move around. People are people, not plañís.* "Do you love the audience?" Certainly we do. We show it by getting out of their way. (Art and money are in this world together, and they need each other to keep on going. Perhaps they're both on their way out. Money'll be-rnmp a rredit rard without a monthlv bilí. What'll art become? A familv reunión?

If so, let's have it with people in the round, each individual free to lend his attention wherever he will. Meeting house.) VI. After an Oriental decade, a Tibetan Bikku returned to Toronto to teach. He told me that were he to speak the truth his audience would drop to six. Instead he gives lectures transmitüng not the spirit but the understandable letter. Two hundred people listen on each occasion. all of them deeply moved. (Art's a way we have for throwing out ideas—ones we've picked up in or out of our heads. What's marvelous is that as we throw them out—these ideas—they genérate others, ones that weren't even in our heads to begin with.) Charles Ivés had this idea: the audience is any one of us,just a human being. He sits in a rocking chair on a verandah. Looking out toward the mountains, he sees the setting sun and hears his own symphony: it's nothing bui the sounds haüDenine in the air around him.

RoyAscott

'Behaviourist Art and the Cybernetic Vision"

(1966-1967)

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RoyAscott. Photo byjosephine Coy. Courtesy of Roy Ascott.

'Ifthe cybernetic spirit constitutes the predominant attitude of the modern era, the computer is the supreme tool that its technology has produced. Used in conjunction with synthetic materials it can be expected to open up paths of radical change and invention in art.... The interaction of man and computer in some creative endeavor, involving the heightening ofimaginative thought, is to be expected."

95

96 Koy Ascott

« Since the 1960s, the British educator, artist, and theoretidan Roy Ascott has been one of Europe's most active and outspoken practitioners of ¡nteractive computer art. Ten years before the personal computer carne into existence, Ascott saw that ¡nteractivity ¡n computer-based forms of expression would be an emerging ¡ssue in the arts. Intrigued by the possibilities, he built a theoretical framework for approaching ¡nteractive artworks, which brought together certain characteristics of the avant-garde (Dada, surrealism, Fluxus, Happenings, and pop art, in particular) with the science of cybernetics championed by Norbert Wiener.

Ascott's thesis on cybernetic visión ¡n the arts begins with the premise thal interactive art must free itself from the modernist ideal of the "perfect object." Like John Cage, he proposes that the artwork be responsive to the viewer, rathei- than fixed and static. But Ascott expands on Cage's premise ¡n the realm oí computer-based art, suggesting that the "spirit of cybernetics" offers the mos1 effective means for achieving a two-way exchange between the artwork and its audience. Ascott challenges artists to acknowledge information technology as the most significant tool of the age, and insists that it is the artist's obligation to use this technology. Yet, unlike Nam June Paik's visión, Ascott's ¡s not ironic; rather, it is utopian in its embrace of a new médium, excited by the potential of a thrív-ing, dynamic exchange between technology and art to empower the spectator and deepen his or her experience. »

the behavioural tendency in modern art

... By "Modern Art" we mean that cultural continuum of ideas, forms and human activity which differs radically from any previous era and is both expressive and formative of the altitudes and conditions of our time. To describe it as a continuum may seem contradictory to its accepted identity. It is seen popularly as an an-archic, highly diversified and chaotic situation which loses as much in coherence and continuity as it gains in novelty and imagination.

Now, undoubtedly it is anarchic, but in the good sense that interaction between artists is free and not constrained by aesthetic canons or political directives. The diversity of images, structures and ideas which it engenders is far greater than at any other period in history. And it may well seem chaotic; a common cultural consciousness is not readilv aocarent todav. But it is our nurnose to demonstrate that Modern Art is fundamentally of a piece, that there is unity in its diversity, and that the quality which unifies it is in distinct contrast to the essential nature of the art which went before it. We shall describe this quality as "behav-ioural" and we shall show how it evidences our present transition from the oíd deterministic culture to a future shaped by a Cybernetic Vision.

The analysis of this behavioural tendency will be largely confined to one broad área, that of the visual/plástic arts, since there it seems to be most marked, but in a more general sense we shall discuss the arts as a whole, illustrating their convergence and interaction in this context. We shall demónstrate how this unity of approach may be potentially part of a larger unity, an integral culture, em-bracing modern science and technology. And we shall warn how this unity, and the incipient cybernetic visión in art, may be inhibited by artistic altitudes which, out of ignorance and fear, are opposed to radical creative change, and view a cy-bernated society with indifference or hostility.

the general characteristics of modern art

The dominan! feature of art of the past was the wish to transmit a clearly defined message to the spectator as a more or less passive receptor, from the artist as a unique and highly individualised source. This deterministic aesthetic was cen-tred upon the structuring, or "composition," *offacts,* of concepts of the *essence* of things, encapsulated in a factually correct visual field. Modern Art, by contrast, is concerned to initiate *events* and with the forming of concepts *ofexistence.* The visión of art has shifted from the field of objects to the field of behaviour and its function has become less descriptive and more purposive.

Although in Painting and Sculpture the channel of communication remains largely visual, other modalities are increasingly employed—tactile, postural, aural; so that a more inclusive term than "visual" art must be found, and the one we propose is "behavioural." This behavioural tendency dominates art now in all its as-pects. The artist, the artifact and the spectator are all involved in a more behavioural context. We find an insistence on polemic, formal ambiguity and in-stability, uncertainty and room for change in the images and forms of Modern Art. And these factors predominate not for esoteric or obscurantist reasons but to draw the spectator into active participation in the act of creation; to extend him, *vía* the artifact, the opportunity to become involved in creative behaviour on all levéis of experience—physical, emotional and conceptual. A feedback loop is es-tablished so that the evolution of the artwork/experience is governed by the indínate involvement of the spectator. As the process is open-ended the spectator now engages in decision-making play.

Creative Participation

We may say that the boundaries between making art, the artifact itself, and the experience of the work are no longer clearly defined. Or, more precisely. that the tendency for this to be so is evident. There are still in this transitional period many artists who contrive to forcé the new sensibility into oíd moulds,just as in technology there are many industrialists who attempt to squeeze cybernation into a nineteenth-century structure of operations.

The participational, inclusive form of art has as its basic principie "feedback," and it is this loop which makes of the triad artist/artwork/observer an integral whole. For art to switch its role from the prívate, exclusive arena of a rarefied élite to the public, open field of general consciousness, the artist has had to créate more flexible structures and images ofFering a greater variety of readings than were needed in art formerly. This situation, in which the artwork exists in a perpetual state of transition where the effort to establish a final resolution must come from the observer, may be seen in the context of games. We can say that in the past the artist played to win, and so set the conditions that he always domi-nated the play. The spectator was positioned to lose, in the sense that his moves were predetermined and he could form no strategy of his own. Nowadays we are moving towards a situation in which the game is never won but remains perpet-ually in a state of play. While the general context of the art-experience is set by die artist, its evolution in any specific sense is unpredictable and dependent on the total involvement of the spectator.

Where once the function of art was to créate an equilibrium, establish a har-mony on the public level of relatively passive reception, we now find art as a more strident agent of change, effecting ajolt to the whole human organism, a cat-alyst which sets up patterns of behaviour, of thought and emotion, which are unpredictable in any fine sense. We observe in the painting of Poussin, for ex-ample, the wish to fix a set of relationships in the spectator's consciousness, te reinforce these absolutes by the stability of the formal composition; he commu-nicates but by a one-way channel. The modern artist, on the other hand, is pri-marily motivated to initiate a *dialogue,* to set feelings and ideas in motion, te enrich the artistic experience with feedback from the spectator's response.

99 benaviourisr Arr ana rne Lyoernetic visión

This cybernetic process of retraction generales a constant stream of new and nnfamiliar relationships, associative links and concepts. Each artwork becomes *í* sort of behavioural Tarot pack, presenting coordinates which can be endlessly reshufíled by the spectator, always to produce meaning. This is achieved princi-pally in one of two ways: either the artifact has a definitive form but contains only a small amount of low-definition information; or its physical structure is such that its individual constituent parts can change their relationships, either by the direct manipulation of the spectator, or by his shiftiiig viewpoint, or by the agency oí electrical or other natural power. The active involvement of the spectator can be thought of as removing uncertainty about a set of possibilities. Deep involvement and interplay produces information. The "set" of the artwork has variety only in so far as the observer participates. The variety of the set is a measure oi the uncertainty involved. An important characteristic of Modern Art, then, is that it offers a high degree of uncertainty and permits a great intensity of partic-ipation.

As to the artist's role, it can be said to function on two levéis simultaneously, the prívate and the social. In the first case, the primacy of a total behavioural involvement in the activity or *process* of making art is apparent. The artist is not goal-directed in the sense of working towards a predetermined art object. The artifact is essentially the result of his creative behaviour, rather than the reason for it. The growth of a painting or sculpture or environment is of more importance than the achievement of its final form. Indeed, unlike Classical Art, there is no point at which it can be said to have reached a final form. From the social point of view the artist's behaviour is a Ritual in which he acts out the role of the Free Man controlling his world by taking endless risks as he plunges into the un-known territories of Form and Idea. It is a paradigm of a condition to which the human being constantly aspires, where íreedom and responsibility combine to reduce our anxiety of the unknown and unpredictable while enlarging our experi-ence of the unfamiliar and irresistible.

At this early stage of a radically new culture the artist is doing little more than exploring his new relationship to the spectator. He is searching for new ways oi handling ideas, for more flexible and adaptive structures to contain them; he is attempting to genérate new carrier waves for the modulations of contemporaiy experience; and he is searching the resources of technology to expand his reper-toire of skills. His concern is to affirm that dialogue is possible—that is the contení and the message of art now; and that is why, seen from the deterministic poinl of view, art may seem devoid of contení and the artist to have nothing to say. The mndern means of nommuniration. of feedback and viable interolav—these are th(

content of art. The artist's message is that the extensión of creative behaviour into sveryday experience is possible.

The message is timely and apposite at a period in which we can anticipate the reduction of labour to a minimum and expect the creative use of leisure time to be the main preoccupation of our lives. And even if the artist were to have fully explored the new channels of communication and thoroughly exploited the media and techniques of modern technology, it is unlikely that his attitude would change. He would continué to avoid the limitations of an aesthetic geared to the transmission of fmite messages or the formulation of fixed altitudes and absolute valúes. He will continué, instead, to provide a *matrix* for ideas and feelings from which the participants in his work may construct for themselves new experi-ences and unfamiliar patterns of behaviour....

the cybernetic vision in art

By this term we do not mean "the Art of Cybernetics" ñor do we refer to an art concerned to ¿Ilústrate Cybernetics, ñor yet an art embodying cybernetic machines or Robot Art—although any one of these things might be involved at some point, and again, they might not.

We are referring to the spirit of Cybernetics which may inform art and in turn be enriched by it. We contrast the Cybernetic Vision in Art to the Deterministic Vision of the past which has already been outlined. We say of Cybernetics that, befo re it is a method or an applied science, it is a field of knowledge which shapes our philosophy, influences our behaviour and extends our thought.

We are moving towards a fully cybernated society[1] where processes of retraction, instant communication, autonomic flexibility will inform every aspect oi our environment. In that forming society, of which we are a part, the cybernetic spirit finds its expression in the Human Science[2] and in Environmental Technology; the two poles between which we act out our existence. It is the spirit oí our understanding of Ufe at its simplest and most complex levéis, and a large measure of our ability to control it.

The economic and social effects of automation in the cybernated society wil] be profound.[3] The effects of our transition of that future state are already felt, particularly in the United States. Matters of leisure, class formation, political and economic power have already called for revisión and new thinking. Cybernetics already dominates our more advanced concepts of transport, shelters, storage and **nfhpr rlav tn rlav matters nf rnntrnl and rommumration and has ranser] the radical** transformation of many industrial and commercial procedures. The effect oí the computer on human thought is currently the subject of vigorous discussion in academic circles; the man/computer relaüonship is seen to be as much a ques-tion of identity as of methodology.

Fundamentally Cybernetics concerns the idea of the perfectibility of systems: it is concerned in practice with the procurement of effective action by means oi self-organising systems. It recognises the idea of the perfectibility of Man, of the possibility of further evolution in the biológica! and social sphere. In this it shares its optimism with Molecular Biology. Bio-cybernetics, the simulation of living processes, genetic manipulation, the behavioural sciences, automatic environ-ments, together constitute an understanding of the human being which calis for and will in time produce new human valúes and a new morality.

How does the artist stand in relation to these radical changes? On the level of opinions or concepts he is and will be free to accept or reject them. But on the level of deep human experience they will "alter sense ratios or patterns of per-ception steadily and without resistance."[4] The artist is faced with two possibili-ties; either to be carried along in the stream of events, mindlessly, half aware and perhaps bitter and hostile as a result; or he can come to terms with his world, shape it and develop it by understanding its underlying cybernetic characteris-tics. Awareness of these underlying forces will sharpen his perception; the utili-sation of new techniques will enlarge his powers of thought and creative action; he will be empowered to construct a visión in art which will enhance the cyber-nated society as much as it will be enriched by it. Understanding and awareness, in short, are the conditions for optimism in art.

There is reason to suppose that a unity of art, science and human valúes is possible; there is no doubt that it is desirable.[5] More specifically we propose that an essentially *cybernetic* visión could unify and feed such culture. The grounds for supposing that Art has anticipated this integral situation and is pre-pared for it can be found in the emphatically *behavioural* tendency which it dis-plays. Cybernetics is consistent with Behaviourist Art; it can assist in its evolution ¡ust as, in turn, a behavioural synthesis can embody a Cybernetic Vision.

cybernetics and behaviourist art

[t is necessary to differentiate between *"l'esprit cybernétique"*[6] as we have tried to describe it above, and Cybernetics as a descriptive method. Now, art like any process or system can be examined from the cybernetic point of view; it can als

derive technical and theoretical support from this science—as in the past it has done from Optics or Geometry. This is not unimportant since the artist's range can be extended considerably, as we briefly indicate below. But it is important to remember that the Cybernetic Vision in Art, which will unify art with a cyber-nated society, is a matter of "stance," a fundamental attitude to events and human relationships, before it is in any sense a technical or procedural matter.

Behaviourist Art constitutes a retroactive process of human involvement, in which the artifact functions as both matrix and catalyst. As matrix, it is the substance between two sets of behaviours; it neither exists for itself ñor by itself. As a catalyst, it triggers changes in the spectator's total behaviour. Its structure must be adaptive implicitly or physically, to accommodate the spectator's responses, in order that the creative evolution of form and idea may take place. The basic principie *is feedback.* The system Artifact/Observer furnishes its own controlling energy; a function of an output variable (observer response) is to act as an input variable, which introduces more variety into the system and leads to more vari-ety in the output (observer's experience). This rich interplay derives from what is a self-organising system in which there are two controlling factors; one, the spectator is a self-organising sub-system; the other, the artwork is not usually at present homeostatic.

There is no a priori reason why the artifact should not be a self-organising system; an organism, as it were, which derives its initial programme or code from the artist's creative activity, and then evolves its specific artistic identity and function in response to the environments which it encounters. The artist's creative activity is also dependen! on feedback; the changes which he effects in his immediate environment (or "arena") by means of tools and media set up config-urations which feed back to affect his subsequent decisions and actions. Thus Modern Art, with its fundamental behavioural quality, is the art of *the organisa-tion of effects.* And when all the control factors, including the artwork itself, are eíFectively homeostatic, art will be concerned with the automatic control of effects. Cybernetics, of course, is the science of the organisation of effects, and of the automatic control of efFects.[7]

Equally, there is no a priori reason why the artwork *should* become a self-organising system; the basic feedback process of behaviourist art opérales within the conventions of painting and sculpture, provided that they display low defin-ition, múltiple associations and indeterminate contení, within paramelers which are, al leasl implicitly, flexible. And, as we have suggested already, ibis is nowa-days ihe case—even lo ihe extent of providing a more or less emply receplack (ihe canvas) into which the speclalor can projecl his own imaginative world. e.e:., Yves Klein, Ad Reinhard.

the computer and growth systems

However, historically it has been a characteristic of the artist to reach out to the tools and malcriáis which the technology ofhis time producesjust as his percep-tion and patterns of thought have tended to identify with scientific and philo-sophical altitudes of the period. If ihe cybernelics spiril constitutes the predominan! *attitude* of ihe modern era, the computer is ihe supreme *tool* ihat its lechnology has produced. Used in conjunclion wilh synlhelic malcriáis it can be expected to open up paths of radical change and invention in arl. For it is not sim-ply a physical tool in the sense thal an aluminium casling plant or CO_2 welding geai are tools, i.e., extensions of physical power. It is a tool for the mind, an instrumenl for the magnification of thought, potentially an intelligence amplifier.[8] The inter-action of man and computer in some creative endeavour, involving the heighten-ing of imaginative thought, is to be expected. Moreover the interaction of Artifacl and computer, in the context of the behavioural structure, is equally foreseeable.

Experiments are already taking place. We have cited Schoffer's use of a computer in some of his structures. In music lannis Xenakis has made extensive use of an IBM 7090—a process in which he "specifies the duration and density of sound events, leaving the parameters of pitch, velocity and dynamics to the computer." The "Light-Harp" project of Haukeland and Nordheim, an environ-mental sculpture emitting sound in relation to the quality of local light, with sound sources changing position within the structure, calls for a highly sophis-ticated control and Communications system within it.

The computer may be linked to an artwork and the artwork may in some sense *be* a computer. The necessary conditions of behaviourist art are that the spectator is involved and that the artwork in some way *behaves.* Now, it seems likely that in the artist's attempt to créate structures which are probabilistic, the artifact may result from biological modelling. In short, it may be developed with the properties of growth. Cybernetics already furnishes models which could as-sist in this development, e.g., Beer's Fungoid Systems and research into chemi-cal and chemical-colloidal computers.[9] The potential for the future is enormous.[10]

The cybernetic visión not only shapes modern science and technology, integrating and bridging disparate fields of knowledge and improving artificial control and communication systems by the understanding of complex natural processes, but it can be expected to find expression and enlargement in Art. It can assist in the evolution of art. serving to increase its variety and vigour..

riyron mjeger

1 ¿ » "Responsiva Environments" (1977)

Myron Krueger, Videoplace. © *Myron Krueger. Courtesy of Myron Krueger.*

"The responsive environment has been presented as the basis for a new aesthetic médium based on real-time interaction between men and machines. In the long range it augurs a new realm of human experience, artificial realities which seek not to stimuíate the physical world but to define arbitrary, abstract and otherwise Impossible relationships between action and result."

105 nesponsive hnvironmenfs

« Myron Krueger *was* among the first artists to explore the computer as a central component ¡n Interactive art. Originally trained as a computer scientist, Krueger, under the influence of John Cage's experiments ¡n ¡ndeterminacy and audience participaron, pioneered human-computer ¡nteraction ¡n the context oí physical environments. Beginning ¡n 1969, he collaborated with artist and engi-neer colleaguesatthe University of Wisconsin to créate artworks that responded to the movement and gesture of the viewer through an elabórate system of sens-ing floors, graphic tables, and video cameras. In this essay, which reflects the influence of cybernetics on the arts and sciences, Krueger discusses human-computer ¡nteraction as the basis for an emerging art form.

At the heart of Krueger's contribution to interactive computer art was the notion of the artist as a "composer" of intel ligent, real-time computer-mediated spaces, or "responsive environments," as he called them. Krueger "composed" environments ¡n which the computer responded to the gestures of the audience by interpreting, and even anticipating, their actions. In such works as /Wefap/a) and *Videoplace,* both from the 1970s, images of audience members would be pro¡ected on an eight-by-ten-foot screen; superimposed on the screen would be animated figures and special effects designed by the artist. Audience members :ould "touch" each other's video-generated silhouettes, as well as manipúlate the odd, playful assortment of graphical objects and animated organisms that appeared on the screen, imbued with the presence of artificial life.

In Krueger's artworks the images of spectators video-broadcast from sepárate locations would be projected into a single space.This collage effect antici-pated subsequent developments in telepresence, which can be described as the state of being present simultaneously in more than one location. In these early sxplorations of telematic art, audience members experienced a sensation of virtual proximity, as if they were standing next to each other ¡n the same space, though they were separated by a significant distance. This aspect of Krueger's work makes it a precursor to today's global Communications technology, including video-conferencing, networked virtual worlds, and live on-line chat. »

introduction

Man-machine interaction is usually limited to a seated man poking at a machine with his fingers or perhaps waving a wand over a data tablet. Seven years ago, 1 was dissatisfied with such a restricted dialoeue and embarked on research exploring more interesting ways for men and machines to relate. The result was the concept of a responsive environment in which a computer perceives the actions of those who enter and responds intelligently through complex visual and audi-tory displays.

Over a period of time the computer's displays establish a context within which the interaction occurs. It is within this context that the participant chooses his next action and anticipates the environment's response. If the response is unexpected, the environment has changed the context and the participant must reexamine his expectations. The experience is controlled by a composition which anticipates the participant's actions and flirts with his expectations.

This paper describes the evolution of these concepts from their primitive beginnings to my current project, *Videoplace,* which provides a general tool foi devising many interactions. Based on these examples an interactive art form is de-fíned and its promise identified. While the environments described were pre-sented with aesthetic intent, their implications go beyond art. In the final section applications in education, psychology and psychotherapy are suggested.

glowflow

In 1969,1 became involved in the development *oíGlowflow,* a computer art project conceived by Dan Sandin, Jerry Erdman and Richard Venezsky at the University of Wisconsin. It was designed in an atmosphere of encounter between ar and technology. The viewer entered a darkened room in which glowing lines o light defined an illusory space. The display was accomplished by pumping phos phorescent particles through transparent tubes attached to the gallery walls These tubes passed through opaque columns concealing lights which excited th phosphors. A pressure sensitive pad in front of each of the six columns enableí the computer to respond to footsteps by lighting difíerent tubes or changing th sounds generated by a Moog synthesizer or the origin of these sounds. Howeveí the artists' attitude toward the capacity for response was ambivalent. They fe! that it was important that the environment respond, but not that the audience b aware of it. Delays were introduced between the detection of a participant and th computer's response so that the contemplative mood of the environment woul not be destroyed by frantic attempts to elicit more responses.

While *Glowflow* was quite successful visually, it succeeded more as a kineti sculpture than as a responsive environment. However, the *Glowflow* experienc led me to a number of decisions:

3. Interactive art is potentially a richly composable médium quite distinct from the concerns of sculpture, graphic art or music.

4. In order to respond intelligendy the computer should perceive as much as possible about the participant's behavior.
5. In order to focus on the relationships between the environment and the participants, rather than among participants, only a small number ofpeople should be involved at a time.
6. The participants should be aware of how the environment is responding to them.
7. The choice of sound and visual response systems should be dictated bytheir ability to convey a wide variety of conceptual relationships.
8. The visual responses should not be judged as art ñor the sounds as music.The only aesthetic concern is the quality of the interaction.

metaplay

Fbllowing the *Glowflow* experience, I conceived and directed *Metaplay,* which was exhibited in the Memorial Union Gallery of the University of Wisconsin for *í* month in 1970. It was supported by the National Science Foundation, the Computer Science Department, the Gradúate School and the loan of a PDP-12 by Digital Equipment Corporation.

Metaplay focus reflected my reactions to *Glowflow.* Interaction between the parücipants and the environment was emphasized; the computer was used to facilitate a unique real-time relationship between the artist and the participan!. An 8' X 10' rear-projection video screen dominated the gallery. The live video image of the viewer and a computer graphic image drawn by an artist, who was in another building, were superimposed on this screen. Both the viewer and the artist could respond to the resulting image.

Hardware

The image Communications started with an analogue data tablet which enabled the artist to draw or write on the computer screen. The person doing the draw-ing did not have to be an artist, but the term is used for convenience. One video camera, in the Computer Center, was aimed at the display screen of the Adage Graphic Display Computer. A second camera, a mile away in the gallery, picked ud the live imaee of oeople in the room. A televisión cable transmitted the video computer image from the Computer Center to the gallery and the two signáis were mixed so that the computer image overlayed the live image. The compos-ite image was projected on the 8' X 10' screen in the gallery and was simultane-ously transmitted back to the Computer Center where it was displayed on a video monitor providing feedback for the artist.

The artist could draw on the Adage screen using a data tablet. By using func-tion switches, potentiometers and the teletype keyboard the pictures could be rapidly modified or the mode of drawing itself altered. In addition to the eflects of simple drawings, the image could be moved around the screen, image size could be controlled and the picture could be repeated up to ten times on the screen displaced by variable X, Y and size increments. A tail of a fixed number of line segments could be drawn allowing the removal of a segment at one end while another was added at the opposite end. An image could be rotated in 3-space under control of the pen. Although this was not true rotation, the visual ef-fect was similar. A simple set of transformations under potentiometer and tablet control yielded apparent animation of people's outlines. Finally, previously de-fmed images could be recalled or exploded. While it might seem that the drawing could be done without a computer, the ability to rapidly erase, recall and transform images required considerable processing and created a far more pow-eríiil means of expression than pencil and paper could provide.

Interaction

These facilities provided a rich repertoire for an unusual dialogue. The artist could draw pictures on the participants' images or communicate directly by writing words on the screen. He could induce people to play a game like Tic-Tac-Toe or play with the act of drawing, starting to draw one kind of picture only to have it transformed into another by interpolation.

Live Grqffiti

One interaction derived from the artist's ability to draw on the image of the audience. He could add grafEti-like features or animate a drawn outline of a persori so that it appeared to dance to the music in the gallery. The artist tried various approaches to involve people in the interaction. Failing to engage one person, he would seek someone more responsive.

It was important to involve the participants in the act of drawing. However the electronic wand designed for this purpose did not work reliably. Whal evolved was a serendipítous solution. One day as I was trying to draw on a stu-dent's hand, he became confused and moved it. When I erased my scribblings and started over, he moved his hand again. He did this repeatedly until it became a game. Finally, it degenerated to the point where I was simply tracking the image of his hand with the computer line. In effect, by moving his hand he could draw on the screen before him.

The relationship established with this participan! was developed as one of the major themes *ofMetaplay.* It was repeated and varied until it became an aesthetic médium in itself. With each person we involved in this way, we tried to preserve the pleasure of the original discovery. After playing some graffiti games with each group that entered, we would focus on a single individual and draw around the image of his hand. After an initial reaction of blank bewilderment, the self-conscious person would make a nervous gesture. The computer line traced the gesture. A second gesture, followed by the line, was the key to discovery. One could draw on the video screen with his finger! Others in the group, observing this phenomenon, would want to try it too. The line could be passed from one person's finger to another's. Literally hundreds of interactive vignettes developed within this simple communication channel.

Drawing by this method was a rough process. Pictures of any but the simplest shapes were unattainable. This was mainly because of the difficulty of tracking a person's finger. Happily, neither the artist ñor the audience was concerned about the quality of the drawings. What was exciting was interacting in this novel way through a man-computer-video link spanning a mile.

psychic space

The next step in the evolution of the responsive environment was *Psychic Space,* which I designed and exhibited in the Memorial Union Gallery during May and fuñe of 1971. It was implemented with the help of my students, the Computer Science Department and a National Science Foundation grant in Complex Information Processing.

Psychic Space was both an instrument for musical expression and a richly composed, interactive, visual experience. Participants could become involved in i softshoe duet with the environment, or they could attempt to match wits with the computer by walking an unpredictable maze projected on an 8' X 10' video

A PDP-11 had direct control of all sensing and sound in the gallery. In addition, it communicated with the Adage AGT-10 Graphic Display Computer at the Computer Center. The Adage image was transmitted over video cable to the gallery where it was rear-projected on the 8' X 10' screen. The participant's po-sition on the floor was the basis for each of the interactions. The sensing was done by a 16' X 24' grid of pressure switches, constructed in 2' X 4' modules, each containing 8 switches. Since they were electronically independent, the system was able to discrimínate among individuáis if several were present. This inde-pendence made it easy for the programming to ignore a faulty switch until its module was replaced or repaired. Since there were 16 bits in the input words of the PDP-11, it was natural to read the 16 switches in each row across the room in parallel. Digital circuitry was then used to sean the 24 rows under computer control.

Input and Interaction

Since the goal was to encourage the participants to express themselves through the environment, the program automatically responded to the footsteps of peo-ple entering the room with electronic sound. We experimented with a number of difieren! schemes for actually generating the sounds based on an analysis of peo-ples' footsteps. In sampling the floor 60 times per second we discovered that a single footstep consisted of as many as four discrete events: lifting the heel, lift-ing the toe, putting the heel down and putting the ball of the foot down. The first two were dubbed the "unfootstep." We could respond to each footstep or un-footstep as it occurred, or we could respond to the person's average position. A number of response schemes were tried, but the most pleasing was to start each tone only when a new switch was stepped on and then to terminate it on the next "unfootstep." Thus it was possible to get silence by jumping, or by lifting one foot, or by putting both feet on the same switch.

Typical reaction to the sounds was instant understanding, followed by a rapid-fire sequence of steps,jumps and rolls. This phase was followed by a slower, more thoughtful exploration of the environment in which more subtle and interesting relationships could be developed. In the second phase, the participaní would discover that the room was organized with high notes at one end and lov* notes at the other. After a while, the keyboard was abruptly rotated by 90 degrees

After a lonser period of time an additional feature carne into play. If the computer discovered that a person's behavior was characterized by a short series of steps punctuated by relatively long pauses, it would use the pause to establish a new kind of relationship. The sequence of steps was responded to with a series of notes as before; however, during the pause the computer would repeat these notes again. If the person remained still during the pause, the computer assumed that the relationship was understood. The next sequence of steps was echoed at a noticeably higher pitch. Subsequent sequences were repeated several times with variations each time. This interaction was experimental and extremely difficult to introduce clearly with feedback alone, i.e., without explicit instructions. The desire was for a man-machine dialogue resembling the guitar duel in the film *Deliverance.*

maze—A composed environment

The maze program focused on the interaction between one individual and the environment. The participant was lured into attempting to navigate a projected maze. The intrigue derived from the maze's responses, a carefully composed sequence of relations designed to constitute a unique and coherent experience.

Hardware

The maze itself was not programmed on the PDP-11, but on the Adage located a mile away in the Computer Center. The PDP-11 transmitted the participant's floor coordinates across an audio cable to the Adage. The data was transmitted asynchronously as a serial bit stream of varying pulse widths. The Adage generated the maze image which was picked up by a TV camera and transmitted via a video cable back to the Union where it was rear-screen-projected to a size of

Interaction

The first problem was simply to edúcate the person to the relationships between the floor and the screen. Initially, a diamond with a cross in it representing the person's position appeared on the screen. Physical movement in the room caused the symbol to move correspondingly on the screen. As the participant ap-proached the screen, the symbol moved up. As he moved away, it moved down. rhe next step was to induce the person to move to the starting point of the maze, which had not yet appeared on the screen. To this end, another object was placee on the screen at the position which would be the starting point of the maze. Thi viewer unavoidably wondered what would happen if he walked his symbol to thi object. The arrival of his symbol at the starting point caused the object to vanisl and the maze to appear. Thus confronted with the maze, no one questioned thi inevitability of walking it.

Software Boundaries

Since there were no physical constraints in the gallery, the boundaries of th< maze had to be enforced by the computen Each attempt to viólate a boundary wa foiled by one of many responses in the computer's repertoire. The compute could move the line, stretch it elastically, or move the whole maze. The line coulí disappear, seemingly removing the barrier, except that the rest of the maze woul< change simultaneously so no advantage was gained. In addition, the symbol representing the person could split in half at the violated boundary, with one ha] held stationary while the other half, the alter ego, continued to track movement However, no progress could be made until the halves of the symbol were reunited at the violated boundary.

Even when the participant was moving legally, there were changes in the program contingent upon his position. Several times, as the goal was approached. th< maze changed to thwart immediate success. Or, the relationship between th< floor and the maze was altered so that movements that once resulted in vertica motion now resulted in horizontal motion. Alternatively, the symbol represen! ing the participant could remain stationary while the maze moved.

Ultimately, success was not allowed. When reaching the goal seemed imminent, additional boundaries appeared in front of and behind the symbol, boxinj it in. At this point, the maze slowly shrank to nothing. While the goal could no be reached, the composed frustration made the route interesting.

Experience

The maze experience conveyed a unique set of feelings. The video display spaa created a sense of detachment enhanced by the displaced feedback: movemen on the horizontal plañe of the floor translated onto the vertical plañe of the screen The popular stereotype of dehumanizing technology seemed fulfilled. However the maze idea was engaeine; and people became involved willindv. The lack o *any* other sensation focused attention completely on this interaction. As the ex-perience progressed, their perception of the maze changed. From the initial im-pression that it was a problem to solve, they moved to the realización that the maze was a vehicle for whimsy, playing with the concept of a maze and poking fun at their compulsión to walk it.

videoplace

For the past two years I have been working on a project called *Videoplace,* under the aegis of the Space Science and Engineering Center of the University of Wis-consin. This work is funded by the National Endowment for the Arts and the Wisconsin Arts Board. A preliminary versión was exhibited at the Milwaukee Art Center for six weeks beginning in October 1975. The development of *Videoplace* is still under way and several more years will be required before its potential is fully realized both in terms of implementing the enabling hardware and explor-ing its compositional possibilities.

Videoplace is a conceptual environment with no physical existence. It unites people in sepárate locations in a common visual experience, allowing them to in-teract in unexpected ways through the video médium. The term *Videoplace* is based on the premise that the act of communication creates a place that consists of all the information that the participants share at that moment. When people are in the same room, the physical and communication places are the same. When the communicants are separated by distance, as in a telephone conversation, there is still a sense of being together although sight and touch are not possible. By using televisión instead of telephone, *Videoplace* seeks to augment this sense of place by including visión, physical dimensión and a new interpretation of touch.

Videoplace consists of two or more idéntica! environments which can be ad¡acent or hundreds of miles apart. In each environment, a single person walks into a darkened room where he fmds himself confronted by an 8' X 10' rear-view pro-¡ection screen. On the screen he sees his own life-size image and the image of one or more other people. This is surprising in itself, since he is alone in the room. The other images are of people in the other environments. They see the same Domposite image on their screens. The visual effect is of several people in the same room. By moving around their respective rooms, thus moving their imites, the participants can interact within the limitations nf rhp

It is these apparent limitations that I am currently working to overeóme. Wlien people are physically together, they can talk, move around the same space. manipúlate the same objects and touch each other. All of these actions would ap-pear to be impossible within the *Videoplace.* However, the opposite is true. The *video* médium has the potential of being more rich and variable in some ways than reality itself.

It would be easy to allow the participants to talk, although I usually preclude this, to forcé people to focus on the less familiar kinds of interaction that the *video* médium pro vides. A sense of dimensión can be created with the help oí computer graphics, which can define a room or another spatial context withiri which the participants appear to move around. Graphics can also furnish this space with artificial objects and inhábil it with imaginary organisms. The sense of touch would seem to be impossible to duplicate. However, since the cameras see each person's image in contrast to a neutral background, it is easy to digitize the outline and to determine its orientation on the screen. It is also easy to tell iJ one person's image touches another's, or if someone touches a computer graphic object. Given this information the computer can make the sense of touch effec-tive. It can currently respond with sounds when two images touch and will ulti-mately allow a person's image to pick up a graphic object and move it about the screen.

While the participants' bodies are bound by physical laws such as gravity their images could be moved around the screen, shrunk, rotated, colorized anc keyed together in arbitrary ways. Thus, the full power of video processing coulc be used to medíate the interaction and the usual laws of cause and effect replacec with alternatives composed by the artist.

The impact of the experience will derive from the fact that each person ha; a very proprietary feeling towards his own image. What happens to his imagí happens to him. In fact, when one person's image overlaps another's, there is ; psychological sensation akin to touch. In *Videoplace,* this sensation can be en hanced in a number of ways. One image can occlude the other. Both images caí disappear where they intersect. Both images can disappear except where they in tersect. The intersection of two images can be used to form a window into an other scene so two participants have to cooperate to see a third.

Videoplace need not involve more than one participant. It is quite possible t créate a compelling experience for one person by projecting him into this ima^ inary domain alone. In fact the hardware/software system underlying *Videopkn* is not conceived as a single work but as a general facility for exploring all the po:

response Is the médium

The environments described suggest a new art médium based on a commitment to real-time interaction between men and machines. The médium is comprised of sensing, display and control systems. It accepts inputs from or about the participant and then outputs in a way he can recognize as corresponding to his be-havior. The relationship between inputs and outputs is arbitrary and variable, allowing the artist to intervene between the participant's action and the results perceived. Thus, for example, the participant's physical movement can cause sounds or his voice can be used to navigate a computer-defined visual space. Il is the composition of these relationships between action and response that is important. The beauty of the visual and aural response is secondary. Response is the médium!

The distinguishing aspect of the médium is, of course, the fact that it responds to the viewer in an interesting way. In order to do this, it must know as much as possible about what the participant is doing. It cannot respond intelli§endy if it is unable to distinguish various kinds of behavior as they occur.

The environment might be able to respond to the participant's position, roice volume or pitch, position relative to prior position or the time elapsed since the last movement. It could also respond to every third movement, the rate of movement, posture, height, colors of clothing or time elapsed since the per-son entered the room. If there were several people in the room, it might respond to the distance separating them, the average of their positions or the computer's ibility to resolve them, i.e., respond differently when they are very ciόse to-a;ether.

In more complex interactions like the maze, the computer can créate a context within which the interaction occurs. This context is an artificial reality widiin ivhich the artist has complete control of the laws of cause and effect. Thus the ac-dons perceived by the hardware sensors are tested for significance within the cur-rent context. The computer asks if the person has crossed the boundary in the maze or has touched the image of a particular object. At a higher level the machine can learn about the individual and judge from its past experience with similar individuáis just which responses would be most eñective.

Currently, these systems are constrained by the total inability of the comouter to make certain very useful and for the human very simple perceptual judg-ments, such as whether a given individual is a man or a woman or is voune: or oíd.

rhe perceptual system will define the limits of meaningful interaction, for the enkdronment cannot respond to what it cannot perceive. To date the sensing sys-tems have included pressure pads, ultrasonics and video digitizing.

As mentioned before, the actual means of output are not as important in this médium as they would be if the form were conceived as solely visual or auditory. In fact, it may be desirable that the output not qualify as beautiful in any sense. for that would distract from the central theme: the relationship established be-tween the observer and the environment. Artists are fully capable of producing effective displays in a number of media. This fact is well known and to duplicate it produces nothing new. What is not known and remains to be tested is the va-lidity of a responsive aesthetic.

It is necessary that the output media be capable of displaying intelligent, or at least composed, reactions, so that the participant knows which of his actions provoked it and what the relationship of the response is to his action. The pur-pose of the displays is to communicate the relationships that the environment is trying to establish. They must be capable of great variation and fine control. The response can be expressed in light, sound, mechanical movement, or through any means that can be perceived. So far computer graphics, video generators, light ar-rays and sound synthesizers have been used.

control and composition

The control system includes hardware and software control of all inputs and outputs as well as processing for decisions that are programmed by the artist. He must balance his desire for interesting relationships against the commitment to respond in real-time. The simplest responses are little more than direct feed-back of the participant's behavior, allowing the environment to show offits perceptual system. But far more sophisticated results are possible. In fact, a given aggregation of hardware sensors, displays and processors can be viewed as an in-strument which can be programmed by artists with differing sensitivities to créate completely diñerent experiences. The environment can be thought of in the following ways:

1. An entity which engages the participant in a dialogue. The environment ex-presses itself through light and sound while the participant communicates

with physical motion. Since the experience is an encounter between individuáis, it mieht legitimately include greetings, introductions and

farewells—all in an abstract rather than literal way. The problem is to provide an interesting personality for the environment.

14. A personal amplifier. One individual uses the environment to enhance hisability to interact with those within it. To the participants the interactionmight appear similar to that described above. The result would be limitedby the speed of the artist's response but improved by his sensitivity to theparticipants' moods. The live drawing interaction in *Metaplay* could beconsidered an example of this approach.

15. An environment which has sub-environments with diñerent response relationships. This space could be inhabited by artificial organisms defined either visually or with sound. These creatures can interact with the participants as they move about the room.

16. An amplifier of physical position in a real or artificially generated space.Movements around the environment would result in much larger apparentmovements in the visually represented space. A graphic display computercan be used to genérate a perspective view of a modelled space as it wouldappear if the participant were within it. Movements in the room would result in changes in the display, so that by moving only five feet within the environment, the participant would appear to have moved fifty feet in thedisplay. The rules of the modelled space can be totally arbitrary and phys-ically impossible, e.g., a space where objects recede when you approachthem.

17. An instrument which the participants play by moving about the space. In*Psychic Space* the floor was used as a keyboard for a simple musical instrument.

18. A means of turning the participant's body into an instrument. His physical posture would be determined from a digitized video image and the ori-entation of the limbs would be used to control lights and sounds.

7. A game between the computer and the participant. This variation is reallya far more involving extensión of the pinball machine, already the most commercially successíul interactive environment.

3. An experimental parable where the theme is illustrated by the things that happen to the protagonist—the participant. Viewed from this perspective. the maze in *Psychic Space* becomes pregnant with meaning. It was impossible to succeed, to solve the maze. This could be a frustrating experience if one were trying to reach the goal. If, on the other hand, the

participant maintained an active curiosity about how the maze would thwart him next, the experience was entertainine. Such ooetic corrmositinn nf evnpripnrp i«

one of the most promising lines of development to be pursued with the environments.

[mplications of the art form

Por the artist the environment augurs new relationships with his audience and his irt. He opérales at a metalevel. The participant provides the direct performance of the experience. The environmental hardware is the instrument. The com-puter acts much as an orchestra conductor controlling the broad relationships while the artist provides the score to which both performer and conductor are bound. This relationship may be a familiar one for the musical composer, al-though even he is accustomed to being able to recognize one of his pieces, no matter who is interpreting it. But the artist's responsibilities here become even broader than those of a composer who typically defines a detailed sequence o: events. He is composing a sequence of possibilities, many of which will not be re-alized for any given participant who fails to take the particular path along which they lie.

Since the artist is not dedicated to the idea that his entire piece be expenenced he can deal with contingencies. He can try different approaches, dirFeren: ways of trying to elicit participation. He can take into account the differences among people. In the past, art has often been a one-shot, hit-or-miss propositíon. A painting could accept any attention paid it, but could do little to maintain in-terest once it had started to wane. In an environment the loss of attention can be sensed as a person walks away. The médium can try to regain attention and upor. failure, try again. The piece has a second strike capability. In fact it can learn te improve its performance, responding not only to the moment but also to the entire history of its experience.

In the environment, the participant is confronted with a completely new kind of experience. He is stripped of his informed expectations and forced to deal with the moment in its own terms. He is actively involved, discovering that his limbs have been given new meaning and that he can express himself in new ways. He does not simply admire the work of the artist; he shares in its creation. The experience he achieves will be unique to his movements and may go beyond the in-tentions of the artist or his understanding of the possibüities of the piece.

Finally, in an exciting and frightening way, the environments dramatize the ex-tent to which we are savages in a world of our own creation. The layman has ex-tremelv little ahilitv to define the limits of what is oossible with curren: technology and so will accept all sorts of cues as representing relationships which in fact do not exist. The constant birth of such superstitions indicates how much *we* have already accomplished in mastering our natural environment and how dif-Scult the initial discoveries must have been.

applications

The responsive environment is not limited to aesthetic expression. It is a potent tool with applications in many fields. *Videoplace* clearly generalizes the act oi telecommunication. It créales a form of communication so powerful that two people might choose to meet visually, even if it were possible for them to mee) physically. While it is not immediately obvious that *Videoplace* is the optimum means of telecommunication, it is reasonably fair to say that it provides an infi-nitely richer interaction than Picturephone allows. It broadens the range of pos-dbilities beyond current efforts at teleconferencing. Even in its fetal stage. *Videoplace* is far more flexible than the telephone is after one hundred years of de-relopment. At a time when the cost of transportation is increasing and fiber op-tics promise to reduce the cost of communication, it seems appropriate to research the act of communication in an intuitive sense as well as in the strictly scientific and problem-solving approaches that prevail today....

conclusión

The responsive environment has been presented as the basis for a new aesthetic médium based on real-time interaction between men and machines. In the long range it augurs a new realm of human experience, artificial realities which seek not to simúlate the physical world but to define arbitrary, abstract and otherwise impossible relationships between action and result. In addition, it has been sug-2;ested that the concepts and tools of the responsive environments can be fruit-íully applied in a number of fields.

What perhaps has been obscured is that these concepts are the result of a personal need to understand and express the essence of the computer in humanis-ic terms. An earlier project to teach people how to use the computer was iandoned in favor of exhibits which taught people about the computer by let-ng them experience it. *Metaplay, Psychic Space* and *Videoplace* were designed *>communicate an aíñrmaúve visión oftechnoloev to the ¡av oublic. This level*

of education is importan!, for our culture cannot continué if a large proportion of our population is hostile to the tools that define it.

We are incredibly attuned to the idea that the solé purpose of our technolog} is to solve problems. It also créales concepts and philosophy. We must more fulr; explore these aspects of our inventions, because the next generation of technol ogy will speak to us, understand us, and perceive our behavior. It will enter ever home and office and intercede between us and much of the information and e> perience we receive. The design of such intimate technology is an aesthelic issu as much as an engineering one. We must recognize this if we are to understan and choose what we become as a result of what we have made.

Alan Kay

"User InterFace: A Personal Víew" (1989)

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Alan Kay. Courtesy ofAlan Kay.

"Therefore, let me argüe that the actual dawn of user interface design fírst happened when computer designers finally notíced, notjust that end users had functioning minds, but that a better understand'mg ofhow those minds worked would completely shíft the paradigm of interaction."

During the late 1960s, while a gradúate student at the University of Utah Man Kay studied with Ivan Sutherland, the pioneering scientist whose worl launched the field of Interactive computer graphics. In 1968 he attended Doug las Engelbart's historie presentation of the oN Une System, which ¡ntroduced thi mouse to computing, suggesting for the first time the possibility of "navigating' information space. In the early 1970s, after forming the Learning Researcl Group atthe newly founded Xerox PARC (Palo Alto Research Center), Kay synthesized these influences ¡nto what is considered the most crucial advancemen of human-computer interactivity, the graphical user ¡nterface (GUI). Kay devel oped the ¡dea of iconic, graphical representations of computing functions—th> folders, menus, and overlapping Windows found on the desktop—based on hi research into the intuitive processes of learning and creativity.

The GUI was an entirely new approach to Interactive computing.The fundamentáis of the computer ¡nterface had received scant attention since the birth c the first digital computer, ENIAC, twenty-five years before. At the time, computers were programmed and operated almost exclusively by scientists. Kay realized early on that designing an intuitive, easy-to-use ¡nterface required a subtl understanding of the dynamics of human perception. IMorbert Wiener's concep of the digital computer had been modeled after the brain, with its sophisticate network of message passing and synoptic relays. Kay went deeper ¡n this direction. He drew on the theories of psychologists Jean Piaget, Seymour Papert, an Jerome Bruner, who had studied the intuitive capacities for learning present i the child's mind, and the role that images and symbols play ¡n the building c complex concepts. Kay carne to understand, as he put ¡t, that "doing with image makes symbols."This was the premise behind the GUI, which enabled compul ers users to formúlate ideas ¡n real time by manipulating icons on the compute screen.

Kay's approach made computers accessible to nonspecialists. More impoitant, it transformed the computer into a vehicle for popular creative expressiot In this essay, Kay describes his realization that the computer was not just computational device but a médium ¡n its own right. Computers, Kay recoc nized, might one day replace books.This led him to build a prototype for a peí sonal computer, the Dynabook, which would be capable of dynamical representing images and concepts. This notebook-sized computer, able to provic unprecedented access to information, images, sound, and animation, was a re' olutionary departure not only from the stasis of the book but also from the pa sivity of televisión. While the Dynabook was never built, it led to the Xerox Alt the first true multimedia machine. »

Wnen I was asked to write this chapter, my first reaction was "A book on user interface design—does that mean it's now a real subject?" Well, as of 1989, it's still yes and no. User interface has certainly been a hot topic for discussion since the advent of the Macintosh. Everyone seems to want user interface but they are not sure whether they should order it by the yard or by the ton. Many are just now discovering that user interface is not a sandwich spread—applying the Macintosh style to poorly designed applications and machines is like trying to put Béarnaise sauce on a hotdog!

Of course the practice of user interface design has been around at least since humans invented tools. The unknown designer who first put a haft on a hand axe was trying not just to increase leverage but also to make it an extensión of the *arm,* not just the fist. The evolutionary designer whom Richard Dawkins calis the Blind Watchmaker has been at it much longer; all of life's star-tling interfitness is the result. A more recent byproduct of the industrial revo-lution called *ergonomics* in Europe and *human factors* in the U.S. has studied how the human body uses senses and limbs to work with tools. From the ear-liest use of interactive computing in the fifties—mostly for air traffic control and defense—there have been attempts at user interface design and application of ergonomic principies. Many familiar components of modern user interface design appeared in the fifties and early sixties, including pointing devices, win-dows, menus, icons, gesture recognition, hypermedia, the first personal com-puter, and more. There was even a beautiíully designed user interface for an end-user system in JOSS—but its significance was appreciated only by its designer and users.

Therefore, let me argüe that the actual dawn of user interface design first happened when computer designers finally noticed, not just that end users had functioning minds, but that a better understanding of how those minds worked would completely shift the paradigm of interaction.

This enormous change in point of view happened to many computerists in the late sixties, especially in the ARPA research community. Everyone had theii own catalyst. For me it was the FLEX machine, an early desktop personal computer of the late sixties designed by Ed Cheadle and myself.

Based on much previous work by others, it had a tablet as a pointing device, a high-resolution display for text and animated graphics, and múltiple windows and it directly executed a high-level object-oriented end-user simulation lan-guage. And of course it had a "user interface," but one that repelled end users in-stead of drawing them closer to the hearth. I recently revisited the FLEX machint design and was surprised to find how modern its components were—even a use of icon-like structures to access previous work.

But the combination of ingredients didn't gel. It was like trying to bake a pie from random ingredients in a kitchen: baloney instead of apples, ground-up Cheerios instead of flour, etc.

Then, starting in the summer of 1968,1 got hit on the head randomly but re-peatedly by some really nifty work. The first was just a little piece of glass at the University of Illinois. But the glass had tiny glowing dots that showed text char-acters. It was the first flat-screen display. I and several other grad students won-dered when the surface could become large and inexpensive enough to be a useful display. We also wondered when the FLEX machine silicon could become small enough to fit on the back of the display. The answer to both seemed to be the late seventies or early eighties. Then we could all have an inexpensive powerful notebook computer—I called it a "personal computer" then, but I was thinking *intimacy.*

I read McLuhan's *Understanding Media* [1964] and understood that the most important thing about any Communications médium is that message receipt is really message recovery; anyone who wishes to receive a message em-bedded in a médium must first have internalized the médium so it can be "subtracted" out to leave the message behind. When he said "the médium is the message" he meant that you have to *become* the médium if you use it.

That's pretty scary. It means that even though humans are the animáis that shape tools, it is in the nature of tools and man that learning to use tools reshapes us. So the "message" of the printed book is, first, its availability to individuáis, henee, its potential detachment from extant social processes; second, the uni-formity, even coldness, of noniconic type, which detaches readers from the vivid-ness of the now and the slavery of commonsense thought to propel them into a far more abstract realm in which ideas that don't have easy visualizations can be treated.

McLuhan's claim that the printing press was the dominant forcé that transformed the hermeneutic Middle Ages into our scientific society should not be taken too lightly—especially because the main point is that the press didn't do it just by making books more available, it did it by changing the thought patterns of those who learned to read.

Though much of what McLuhan wrote was obscure and arguable, the sum total to me was a shock that reverberates even now. The computer is a médium! I had always thought of it as a tool, perhaps a vehicle—a much weaker concep-tion. What McLuhan was savine: is that if the personal computer is a truly ne\\ médium then the very use of it would actually change the thought patterns of an entire civilization. He had certainly been right about the effects of the electronic stained-glass window that was televisión—a remedievalizing tribal influence at best. The intensely interactive and involving nature of the personal computer seemed an antiparticle that could annihilate the passive boredom invoked by televisión. But it also promised to surpass the book to bring about a new kind of renaissance by going beyond static representations to dynamic simulation. What kind of a thinker would you become if you grew up with an active simulator connected, not just to one point of view, but to all the points of view of the ages represented so they could be dynamically tried out and compared? I named the notebook-sized computer idea the Dynabook to capture McLuhan's metaphor in the silicon to come.

Shortly after reading McLuhan, I visited Wally Feurzeig, Seymour Papert, and Cynthia Solomon at one of the earliest LOGO tests within a school. I was amazed to see children writing programs (often recursive) that generated poetry, created arithmetic environments, and translated English into Pig Latin. And they were just starting to work with the new wastepaper-basket-sized turtle that roamed over sheets of butcher paper making drawings with its pen.

I was possessed by the analogy between print literacy and LOGO. While designing the FLEX machine I had believed that end users needed to be able to program before the computer could become truly theirs—but here was a real demonstration, and with children! The ability to "read" a médium means you can *access* malcriáis and tools created by others. The ability to "write" in a médium means you can *genérate* malcriáis and tools for others. You must have both lo be lilerale. In prinl writing, the tools you genérate are rhelorical; ihey demonslrate and convince. In computer writing, the tools you genérate are processes; they simúlate and decide.

If the computer is only a vehicle, perhaps you can wait unlil high school lo give "driver's ed" on il—but if it's a médium, then it must be extended all ihe way inlo the world of the child. How to do it? Of course it has to be done on the inlimale nolebook-sized Dynabook! Bul how would anyone "read" ihe Dynabook, leí alone "wrile" on il?

LOGO showed ihal a special language designed with ihe end user's characlerislics in mind could be more successful ihan a random hack. How had Papert learned aboul the nature of children's ihoughl? From Jean Piaget, ihe doyen of European cognilive psychologisls. One of his most imporlanl conlribulions is ihe idea ihat children go dirough several distinctive intellectual slages as ihey develop frr>m birth to maturilv. Much can be accomplished if the nalure of the stages is beeded and much grief to the child can be caused if the stages are ignored. Piaget noticed a kinesthetic stage, a visual stage, and a symbolic stage. An example is that children in the visual stage, when shown a squat glass of water poured into a tall thin one, will say there is more water in the tall thin one even though the pour-ing was done in front of their eyes.

One of the ways Papert used Piaget's ideas was to realize that young children are not well equiped to do "standard" symbolic mathematics until the age of 11 or 12, but that even very young children can do other kinds of math, even ad-vanced math such as topology and differential geometry, when it is presented in a form that is well matched to their current thinking processes. The LOGO tur-tle with its local coordinate system (like the child, it is always at the center of its universe) became a highly successful "microworld" for exploring ideas in differential geometry.

This approach made a big impression on me and got me to read many more psychology books. Most (including Piaget's) were not very useful, but then I discoveredjerome Bruner's *Towards a Theory of Instruction* [1966]. He had re-peated and verified many of Piaget's results, and in the process carne up with a different and much more powerful way to interpret what Piaget had seen. For example, in the water-pouring experiment, after the child asserted there was more water in die tall thin glass, Bruner covered it up with a card and asked again. This time the child said, "There must be the same because where would the water go?" When Bruner took away the card to again reveal the tall thin glass, the child immediately changed back to saying there was more water.

When the cardboard was again interposed the child changed yet again. It was as though one set of processes was doing the reasoning when the child could see the situation, and another set was employed when the child could not see. Bruner's interpretación of experiments like these is one of the most importan! foundations for human-related design. Our mentalium seems to be made up oi múltiple sepárate mentalities with very different characteristics. They reason dif-ferently, have different skills, and often are in conflict. Bruner identified a sepárate mentality with each of Piaget's stages: he called them *enactive, iconic. symbolic.* While not ignoring the existence of other mentalities, he eoncentrated on these three to come up with what are still some of the strongest ideas for ere-ating learning-rich environments.

The work of Papert convinced me that whatever user interface design mighl be, it was solidly intertwined with learning. Bruner convinced me that learning takes place best environmentally and roughly in stage order—it is best to learn somethine: kinestheticallv, then iconically, and finally the intuiüve knowledge wil] be in place that will allow the more powerful but less vivid symbolic processes to work at their strongest. This led me over the years to the pioneers of environ-tnental learning: Montessori Method, Suzuki Violin, and Tim Gallwey's *Inner Game of Tennis,* to namejust a few.

My point here is that as soon as I was ready to look deeply at the human el-ement, and especially after being convinced that the heart of the matter lay with Bruner's múltiple mentality model, I found the knowledge landscape positively festooned with already accomplished useful work. It was like the man in Moliere's *Bourgeois Gentilhomme* who discovered that all his life he had been speaking prose! I suddenly remembered McLuhan: "I don't know who discovered water but it wasn't a fish." Because it is in part the duty of consciousness to represent ourselves to ourselves as simply as possible, we should sorely distrust our commonsense self view. It is likely that this mirrors-within-mirrors problem in which we run into a misleading commonsense notion about ourselves at every turn is what forced psychology to be one of the most recent sciences—if indeed it yet is.

Now, if we agree with the evidence that the human cognitive facilities are made up of a *doing* mentality, an *image* mentality, and a *symbolic* mentality, then any user interface we construct should at least caler to the mechanisms that seem to be there. But how? One approach is to realize that no single mentality offers a complete answer to the entire range of thinking and problem solving. User interface design should intégrate them at least as well as Bruner did in his spiral curriculum ideas.

One of the implications of the Piaget-Bruner decomposition is that the mentalities originated at very different evolutionary times and there is little probability that they can intercommunicate and synergize in more than the most rudimen-tary fashion. In fact, the mentalities are more likely to interfere with each other as they compete for control. The study by Hadamard on math and science creativ-ity [1945] and others on music and the arts indicate strongly that creativity in these áreas is not at all linked to the symbolic mentality (as most theories of teaching suppose), but that the important work in creative áreas is done in the ini-tial two mentalities—most in the iconic (or figurative) and quite a bit in the en-active. The groundbreaking work by Tim Gallwey on the "inner game" [1974] showed what could be done if interference were removed (mentalities not rele-vant to the learning were distracted) and attention was facilitated (the mentalities that could actually do the learning were focused more strongly on the environ-ment).

Finallv. in the sixties a number of studies showed just how modeful was a

rnentality thathad "seized control"—particularly the analytical-problem-solving one (which identifies most strongly with the Bruner symbolic mentality). For example, after working on five analytic tasks in a row, if a problem was given that was trivial to solve íiguratively, the solver could be blocked for hours trying to solve it symbolically. This makes quite a bit of sense when you consider that the main jobs of the three mentalities are:

enactive know where you are, manipúlate**iconic** recognize,
compare, configure, concrete
symbolic de together long chains of reasoning, abstract

The visual system's main Job is to be interested in everything in a scene, to dart over it as one does with a bulletin board, to change context. The symbolic system's main job is to stay with a context and to make indirect connections. Imagine what it would be like if it were reversed. If the visual system looked at the object it first saw in the morning for five hours straight! Or if the symbolic system couldn't hold a thought for more than a few seconds at a time!

It is easy to see that one of the main reasons that the figurative system is so cre-ative is that it tends not to get blocked because of the constant flitting and dart-ing. The chance of finding an interesting pattern is very high. It is not surprising, either, that many people who are "figurative" have extreme diñiculty getting any-thing finished—there is always something new and interesting that pops up to distract. Conversely, the "symbolic" person is good at getting things done, because of the long focus on single contexts, but has a hard time being creative, or even being a good problem solver, because of the extreme tendency to get blocked. In other words, because none of the mentalities is supremely useful to the exclusión of the otriers, the best strategy would be to try to gently forcé syn-ergy between them in the user interface design.

Out of all this carne the main slogan 1 coined to express this goal:

Doing with Images makes Symbols

> The slogan also implies—as did Bruner—that one should start with—be grounded in—the concrete "Doing with Images," and be carried into the more abstract "makes Symbols."

All the ingredients were already around. We were ready to notice what the theoretical frameworks from other fields of Bruner, Gallwey, and others were trying to tell us. What is surprising to me is just how long it took to put it all together. After Xerox PARC provided the opportunity to turn these ideas into reality, it still took our tcrouD about five vears and experiments with hundreds of users to come

up with the first practical design that was in accord with Bruner's model and reilly worked.

DOING

Mouse *enactive* know where you are, manipúlate

with IMAGES

icons, windows *iconic* recognize, compare, configure, concrete

makes SYMBOLS

Smalltalk *symbolic* de together long chains of reasoning, abstract

Part of the reason perhaps was that the theory was much better at confirming that an idea was good than at actually generating the ideas. In fact, in certain áreas like "iconic programming," it actually held back progress, for example, the simple use of icons as signs, because the siren's song of trying to do symbolic thinking iconically was just too strong.

Some of the smaller áreas were obvious and found their place in the frame-work immediately. Probably the most intuitive was the idea of múltiple overlap-ping windows. NLS had múltiple panes, FLEX had múltiple windows, and the bit-map display that we thought was too small, but that was made from individual pixels, led quickly to the idea that windows could appear to overlap. The con-trastive ideas of Bruner suggested that there should always be a way to compare. The flitting-about nature of the iconic mentality suggested that having as many resources showing on the screen as possible would be a good way to encourage creativity and problem solving and prevent blockage. An *intuitive* way to use the windows was to activate the window that the mouse was in and bring it to the "top." This interaction was *modeless* in a special sense of the word. The active window

constituted a mode to be sure—one window might hold a painting kit, another might hold text—but one could get to the next window to do something in *without any special termination.* This is what *modeless* carne to mean for medie user could always get to the next thing desired without any backing out. The contrast of the nice modeless interactions of windows with the clumsy command syntax of most previous systems directly suggested that everything should be made modeless. Thus began a campaign to "get rid of modes."

The object-oriented nature of Smalltalk was very suggestive. For example. *object-oriented* means that the object knows what it can do. In the abstract sym-holir arena, it means we should first write the obiect's ñame (or whatever will fetch it) and then follow with a message it can understand that asks it to do some-thing. In the concrete user-interface arena, it suggests that we should select the object first. It can then furnish us with a menú of what it is willing to do. In both cases we have the *object* first and the *desire* second. This unirles the concrete with the abstract in a highly satisfying way.

The most difEcult área to get to be modeless was a very üny one, that of ele-mentaiy text editing. How to get rid of "inserí" and "replace" modes that had plagued a decade of editors? Several people arrived at the soluüon simultane-ously. My route carne as the result of several beginning programmer adults who were having trouble building a paragraph editor in Smalltalk, a problem I thought should be easy. Over a weekend I built a sample paragraph editor whose main simplification was that it eliminated the distinction between insert, replace, and delete by allowing selections to extend *between* the characters. Thus, there could be a zero-width selection, and thus every operation could be a replace. "Inserf meant replace the zero-width selection. "Delete" meant replace the selection with a zero-width string of characters. I got the tiny one-page program running in Smalltalk and carne in crowing over the victory. Larry Tesler thought it was great and showed me the idea, already working in his new Gypsy editor (which he implemented on the basis of a suggestion from Peter Deutsch). So much for creativity and invention when ideas are in the air. As Goethe noted, the most im-portant thing is to enjoy the thrill of discovery rather than to make vain attempts to claim priority!...

The only stumbling place for this onrushing braver new world is that all oi its marvels will be very difficult to communicate with, because, as always, the user interface design that could make it all simple lags far, far behind. If *communica-tion* is the watchword, then what do we communicate with and how do we do it? We communicate with:

3. Our selves
4. Our tools
5. Our colleagues and others
6. Our agents

Until now, personal computing has concentrated mostly on the first two. Leí us now extend every thing we do to be part of a *grand collaboration—with* one'í self, one's tools, other humans, and, increasingly, with *agents:* computer processeí that act as guide, as coach, and as amanuensis. The user interface design will bt the critical factor in the success of this new way to work and play on the com
puter. One of the implications is that the "network" will not be seen at all, but rather "felt" as a shift in capacity and range from that experienced vía one's own hard disk....

Well, there are so many more new issues that must be explored as well. I say thank goodness for that. How do we navigate in once-again uncharted waters? I have always believed that of all the ways to approach the future, the vehicle that gets you to the most interesting places is Romance. The notion of tool has always been a romantic idea to humankind—from swords to musical instruments to personal computers, it has been easy to say: "The best way to predict the future is to invent it!" The romantic dream of "how nice it would be if..." often has the power to bring the visión to life. Though the notion of management of complex processes has less cachet than that of the hero singlehandedly wielding a sword. the real romance of management is nothing less than the creation of civilizador] itself. What a strange and interesting frontier to investigate. As always, the strongest weapon we have to explore this new world is the one between oui ears—orovidine it's loaded!

JeFFreyShaw

"ModalitiesoF Interactivity and Virtuality" (1992)

Viewer on bicycle,from The Legible City. *Courtesy ofjeffrey Shaw.*

"The traditional activity ofart has been the representation ofreality-manipulating materíals to créate tangible mirrors ofour experíence and desíre. Now with the mechanísms ofthe new digital technologies,

the artwork can become ¡tselfa simulation
ofreality-an im material digital structure
encompass'mg synthetic spaces, which we
can literally enter."

« Since the 1960s, Australian-born artist Jeffrey Shaw has been exploring the 'elationship between interactivity and modes of perception ¡n his performance art, sculpture, videos,and interactive media installations. His interest hasfocused on how perception can be affected by ¡nteractive environments that free the participant from a single, fixed point of view.This work led him to explore the various ways that we might view, interact with, and manipúlate virtual space.This, in turn, brought Shaw to ZKM (Center for New Media) ¡n Karlsruhe, Germany, where he has served as director of the Institute of Visual Media since 1991.

It was in the 1980s that Shaw began to incorpórate virtual reality into his installations.These early works allowed the viewer/participant to move through virtual space by means of an imaginative user-interface device, which Shaw created specifically for each installation. For example, in his 1987 ¡nteractive videodisc sculpture *Invéntenla Terre,* the participant peers into a panorama through a periscope. In his landmark work *The Legible City,* from 1989, the viewer ¡nteracts ¡n real time with projections of an abstract cityscape while riding a stationary bicycle; the viewer's perspective would change as he turned left, right, or carne to a stop. Shaw's work expanded on the responsive environments of Myron Krueger while exploring possibilities for human-computer interaction that moved beyond the confines of the computer screen.They placed the participant inside the virtual environment and, crucially, allowed her to navigate that space through gesture rather than with a mouse. Shaw's work proposed user ¡nterface to be a central aspect of the artwork's aesthetic.»

The research and development of various mechanisms and codes of spatial representation has been a basic preoccupation throughout the history of Western art. The formulation of a set of spatial coordínales provides an underlying aesthetic and existential paradigm within which a culture achieves tentative representation (and thus comprehension) of its desires. The recently developed digital imaging technologies offer the artist new methods and new paradigms which extend the spatial identity of die artwork. And not just in terms of the structure of the image itself, but also in terms of a space of interaction between the image and the spectator. Referring to recent works I have made, I will describe certain important characteristics of the digital image, in particular those aspects which are able to constitute the modalities of interactivity and virtuality in an art-

Painted images hang on walls or rest in storage; bringing them into view is a material handling. Digital pictures reside immaterially inside the computer, and the computer screen íunctions like a window through which the viewer chooses what he wants to look at. Furthermore, the computer screen functions like a cinema camera, because the viewer can pan in any direction over the surface of an image and also zoom into the details of a chosen image. These characteristics ofFer the possibility to créate a virtual space of imagery wherein a three-dimensional structure of relationships between two-dimensional images can be defined. This can then constitute an interactive space which the viewer explores by utilizing some kind of interface device.

In my interactive work *The Narrative Landscape* (Aorta, Amsterdam, 1985). twenty-eight images were arranged on four levéis, each image having a specific spatial location beside, above, and below each other. Using a joysück, the viewer could determine an individual path of movement through this virtual space o: imagery. This joystick gave the viewer interactive control over the movement o the viewing window, which could be panned in any horizontal direction over the surface of an image, and could also be zoomed vertically up and down into the digital detail of an image. This vertical zoom movement also allowed the viewei to penétrate through the image surface, and pass from one image level to an other. Starting from the upper image level the viewer was offered nine difieren pictorial places to enter, each place constituted by a narrative group of threí other images.

The interactive structure of *The Narrative Landscape* shows that the spatia boundaries of the digital image does not have to be defined by the traditiona perimeter of a "picture frame." Instead, a virtual image space of any dimensioi may be created, which the viewer explores by moving his "viewing window.' And as in the cinema, the externalization of the image is always referential to th activity of the viewer's eye (the "camera").

This location of the viewer at the focal plañe of an extended virtual space o imagery was also the modality of my installation *Going to the Heart ofthe Cénit ofthe Carden ofDelights* (Vleeshal, Middelburg, 1986). In this installation, imag changes occurred as a consequence ofthe viewer walking through the museun: from the entrance toward a large video-projected image at the opposite ene These image changes were triggered by infrared sensors placed along a walkwa that was defined by two rows of blue "airport lights" on the floor ofthe museun Furthermore, the sequence of seven image changes was defined in relation t the linear progression of seven vaulted compartments that characterized this mi seum's Gothic architecture. Thus the museum was divided into seven zone

.vliich constituted the spatial coordínales of seven virtual image planes that the idewer passed through when "walking through" this work.

This particular strategy of locating two-dimensional images in a virtual three-dimensional space was also a central aspect of my interactive videodisc sculpture *Inventer la Terre* (La Vülette, París, 1987). This work inherits and dematerializes the tradition of trompe l'oeil panorama painting—the panorama here exists as a true virtual image, positioned around the viewer and superimposed into the actual space of the museum. A periscope-like sculpture contains video and optical mechanisms that enable the viewer to interactively roíate his window of view in-side this panorama, and ihen choose videodisc sequences ihal are "visits" lo "places" that are represented in that panorama.

The three works so far described demónstrate modalities for the location of two-dimensional digital imagery in a virtual three-dimensional space. *The*

Nar-rative Landscape had a specific struclure of image levéis sel behind ihe plañe of the projection screen. *Going to the Heart ofthe Center ofthe Carden ofDelights* implicilly broughl ihese levéis oul in fronl of ihe screen and into the room where the viewer was walking. *Inventer la Terre* could dispense with the screen surface altogelher and achieve an explicil oplical conjunclion of ihe virlual image space and ihe aclual museum space surrounding ihe viewer.

Leí us consider now ihe opporlunilies offered by ihe ihree-dimensional methods of computer visualizalion. If we describe the two-dimensional digital image as a planar ráster of numeric valúes (pixels), then the three-dimensional digital image is a volumetric rasler of numeric valúes (voxels). The viewer's eye position inside ihal volumetric space determines each momenlary displayed or-dering of ihal ráster. Thus a three-dimensional virtual image space can be created which always reveáis itself inleraclively in relalion lo the viewer. "Virlual realily" and "cyberspace" are the fashionable lerms which have come lo be used lo describe ihe technologies which allow a heightened degree of viewer "immersion" in such a virtual image space—technologies which can simúlale the sensual co-ordinales of ihe real world in a new arena of ficlional visualization.

The Legible City (Artec 89, Nagoya, Japan, 1989) was a three-dimensional digilal image whose virlual size was approximalely six square kilomelers. The viewer could interactively travel in ibis space by riding a bicycle which was standing in front of a large video projection screen. The ground plan of this space was based on a number of different cities: Manhallan, Amsterdam, and Karlsruhe. In-slead of buildings lining the avenues and slreels, ihe wriler Dirk Groeneveld wrote a number of stories for this work, and ihe lelters and words of his text conslilule ils whole visual archileclure. In this way ihe cily was Iransformed inlo i kind of three-dimensional book, and bicycling there was an activity of reading where each bicyclist, by choosing his/her own path, made a unique and personal reconstruction of the text. The "real-time" interacüon of the bicycle and the computer-generated image allowed the bicyclist complete freedom to move any-where in this virtual image space.

In *The Legible City,* the space of visualization was virtually located beyond the surface of the projection screen and thus outside the actual room where the bicyclist was situated. In *Alice's Room* (Kanagawa Science Park,Japan, 1989) and *The Virtual Museum (Art Frankfurt,* 1991) I located the virtual imagery inside the actual room where the viewers were standing. Such a digital conjunction of virtual and actual space evokes a mannerist ambiguity—diíferent orders of simulation are located in a meta-dimensional structure that mirrors a confluence of the real and the fictional. This location of the virtual space in a contiguous relationship with the real space establishes a discourse in that fine zone between the virtual and the actual which resembles what Duchamp called "the inframince." It is here that I believe the most interesting and challenging opportunities for artistic propositions exist.

The world is becoming increasingly museified. This tendency towards premature conservation may be relieved by a virtual museum architecture that is as provisional as the culture it embodies. *The Virtual Museum* is a three-dimensional computer-generated museum containing an immaterial constellation of rooms and exhibits. Its apparatus is a round, rotating platform on which is located a large video screen, computing equipment, and a chair on which the viewer sits. From the chair the viewer interactively controls his/her movement through *The Virtual Museum.* Fonvard and backward movement of the chair causes forward and backward movement of the viewer's eye position in the museum space represented on the video screen. Turning the chair causes a rotation of this virtual image space and also a synchronous physical rotation of the platform itself, so that the viewer moves simultaneously in both the virtual and real environments.

The architecture of *The Virtual Museum* is constituted by five rooms, all ot which reproduce the architecture of the real room in which the installation is located, so generating the conjunction of the real and virtual spaces. The first room shows a representation of the installation itself, with its platform, computer, video screen, and chair. Moving through *The Virtual Museum* the viewer in effect transporta himself out of this chair, and so can see the installation represented outside his virtual point of view. The other four rooms are consecutively entered just by

i kind of three-dimensional book, and bicycling there was an activity of reading where each bicyclist, by choosing his/her own path, made a unique and personal reconstruction of the text. The "real-time" interacüon of the bicycle and the computer-generated image allowed the bicyclist complete freedom to move any-where in this virtual image space.

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Hypermedia

VannevarBush

"As WeMayThink" (1945)

VannevarBush and the differential analyzer. Courtesy ofMIT Computer Museum.

"Presumably man's spírít should be elevated ¡fhe can better revíew hís shady past and analyse more completely and objectívely hís present problems. He has buílt a civílization so complex that he needs to méchame his records more fully ifhe ¡s to push his experíment to ¡ts logical conclusión and not merely become bogged down part way there by overtaxing his limíted memory. Hís excursions may be more enjoyable ifhe can reacquíre the privilege of forgetting the manifold things he does not need to have ¡mmedíately at hand, wíth some assurance that he can fínd them again ¡f they prove important."

For the biologists, and particularly for the medical scientists, there can be little indecisión, for their war has hardly required them to leave the oíd paths. Many indeed have been able to carry on their war research in their familiar peace-time laboratories. Their objectives remain much the same.

It is the physicists who have been thrown most violently off stride, who havc left academic pursuits for the making of strange destructive gadgets, who have had to devise new methods for their unanticipated assignments. They have done their part on the devices that made it possible to turn back the enemy, have worked in combined effort with the physicists of our allies. They have felt within themselves the stir of achievement. They have been part of a great team. Now, as peace approaches, one asks where they will find objectives worthy of their best.

Of what lasting beneíit has been man's use of science and of the new instrumente which his research brought into existence? First, they have increased his control of his material environment. They have improved his food, his clothing, his shel-ter; they have increased his security and released him partly from the bondage oi bare existence. They have given him increased knowledge of his own biológica] processes so that he has had a progressive freedom from disease and an increased span of life. They are illuminating the interactions of his physiological and psy-chological íunctions, giving the promise of an improved mental health.

Science has provided the swiftest communication between individuáis; it has provided a record of ideas and has enabled man to manipúlate and to make ex-tracts from that record so that knowledge evolves and endures throughout the life of a race rather than that of an individual.

There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator Is staggered by the findings and conclusions of thousands of other workers—con-:lusions which he cannot find time to grasp, much less to remember, as they ap-pear. Yet specialization becomes increasingly necessary for progress, and the sffort to bridge between disciplines is correspondingly superficial.

Professionally our methods of transmitting and reviewing the results of reiearch are generations oíd and by now are totally inadequate for their purpose. [f the aggregate time spent in writing scholarly works and in reading them could 3e evaluated, the ratio between these amounts of time might well be startling. rhose who conscientiously attempt to keep abreast of current thought, even in estricted fields, by cióse and continuous reading might well shy away from an eximination calculated to show how much of the previous month's efforts could produced on cali. Mendel's concept of the laws of genetics was lost to the wc For a generation because his publication did not reach the few who were capa of grasping and extending it; and this sort of catastrophe is undoubtedly be repeated all about us, as truly significan! attainments become lost in the mas the inconsequential.

The difficulty seems to be, not so much that we publish unduly in view of extent and variety of present day interests, but rather that publication has b extended far beyond our present ability to make real use of the record. The si mation of human experience is being expanded at a prodigious rate, and means we use for threading through the consequent maze to the momentarily portant Ítem is the same as was used in the days of square-rigged ships.

But there are signs of a change as new and powerful instrumentalities ce into use. Photocells capable of seeing things in a physical sense, advanced p tography which can record what is seen or even what is not, thermionic tubes pable of controlling potent forces under the guidance of less power tha mosquito uses to vibrate his wings, cathode ray tubes rendering visible an currence so brief that by comparison a microsecond is a long time, relay con nations which will carry out involved sequences of movements more reli; than any human operator and thousands of times as fast—there are plenty of chanical aids with which to effect a transformation in scientific records.

Two centuries ago Leibnitz invented a calculating machine which emboe most of the essential features of recent keyboard devices, but it could not t come into use. The economics of the situation were against it: the labor invo! in constructing it, before the days of mass production, exceeded the labor t< saved by its use, since all it could accomplish could be duplicated by suffic use of pencil and paper. Moreover, it would have been subject to frequent bri down, so that it could not have been depended upon; for at that time and 1 after, complexity and unreliability were synonymous.

Babbage, even with remarkably generous support for his time, could not ¡ duce his great arithmetical machine. His idea was sound enough, but const tion and maintenance costs were then too heavy. Had a Pharaoh been g detailed and explicit designs of an automobile, and had he understood Ú completely, it would have taxed the resources of his kingdom to have fashic the thousands of parts for a single car, and that car would have broken dowi the first trip to Gi/a.

Machines with interchangeable parts can now be constructed with great e< omy of effort. In spite of much complexity, they perform reliably. Witnes?

üumble typewriter, or the movie camera, or the automobile. Electrical contacts tiave ceased to stick when thoroughly understood. Note the automatic telephone sxchange, which has hundreds of thousands of such contacts, and yet is reliable. A spider web of metal, sealed in a thin glass container, a wire heated to brilliant ^low, in short, the thermionic tube of radio sets, is made by the hundred million, tossed about in packages, plugged into sockets—and it works! Its gossamer parts, the precise location and alignment involved in its construction, would have oc-cupied a master craftsman of the guild for months; now it is built for thirty cents. The world has arrived at an age of cheap complex devices of great reliability; and something is bound to come of it.

A record, if it is to be useful to science, must be continuously extended, it must be stored, and above all it must be consulted. Today we make the record con-ventionally by writing and photography, followed by printing; but we also record on film, on wax disks, and on magnetic wires. Even if utterly new recording pro-cedures do not appear, these present ones are certainly in the process of modifi-cation and extensión.

Certainly progress in photography is not going to stop. Faster material and lenses, more automatic cameras, finer-grained sensitive compounds to allow an extensión of the minicamera idea, are all imminent. Let us project this trend ahead to a logical, if not inevitable, outcome. The camera hound of the future wears on his forehead a lump a little larger than a walnut. It takes pictures 3 mil-limeters square, later to be projected or enlarged, which after all involves only a factor of 10 beyond present practice. The lens is of universal focus, down to any distance accommodated by the unaided eye, simply because it is of short focal length. There is a built-in photocell on the walnut such as we now have on at least one camera, which automatically adjusts exposure for a wide range of illumina-tion. There is film in the walnut for a hundred exposures, and the spring for op-erating its shutter and shifting its film is wound once for all when the film clip is inserted. It produces its result in full color. It may well be stereoscopic, and record with two spaced glass eyes, for striking improvements in stereoscopic technique are just around the córner.

The cord which trips its shutter may reach down a man's sleeve within easy reach of his fingers. A quick squeeze, and the picture is taken. On a pair of ordi-nary glasses is a square of fine lines near the top of one lens, where it is out of *thí* of ordinary visión. When an object appears in that square, it is lined up for its picture. As the scientist of the future moves about the laboratory or the field. svery time he looks at something worthy of the record, he trips the shutter and ín it goes, without even an audible click. Is this all fantastic? The only fantastic thing about it is the idea of making as many pictures as would result from its use.

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Will there be dry photography? It is already here in two forras. When Brady made his Civil War pictures, the píate had to be wet at the time of exposure. Now it has to be wet during development instead. In the future perhaps it need not be wetted at all. There have long been films impregnated with diazo dyes which form a picture without development, so that it is already there as soon as the camera has been operated. An exposure to ammonia gas destroys the unex-posed dye, and the picture can then be taken out into the light and examined. The process is now slow, but someone may speed it up, and it has no grain diíficul-ties such as now keep photographic researchers busy. Often it would be advan-tageous to be able to snap the camera and to look at the picture immediately.

Another process now in use is also slow, and more or less clumsy. For fifty years impregnated papers have been used which turn dark at every point where an electrical contact touches them, by reason of the chemical change thus pro-duced in an iodine compound included in the papen They have been used to make records, for a pointer moving across them can leave a trail behind. If the electrical potential on the pointer is varied as it moves, the line becomes light or dark in accordance with the potential.

This scheme is now used in facsimile transmission. The pointer draws a set of closely spaced lines across the paper one after another. As it moves, its potential is varied in accordance with a varying current received over wires from a dis-tant station, where these variations are produced by a photocell which is similarly scanning a picture. At every instant the darkness of the line being drawn is made equal to the darkness of the point on the picture being observed by the photocell. Thus, when the whole picture has been covered, a replica appears at the re-ceiving end.

A scene itself can be just as well looked over line by line by the photocell in this way as can a photograph of the scene. This whole apparatus constitutes a camera, with the added feature, which can be dispensed with if desired, of making its picture at a distance. It is slow, and the picture is poor in detail. Still, it does give another process of dry photography, in which the picture is finished as soon as it is taken.

It would be a brave man who would predict that such a process will always remain clumsv. slow. and faultv in detail. Televisión eauioment todav transmití sixteen reasonably good pictures a second, and it involves only two essential dif-ferences from the process described above. For one, the record is made by a moving beam of electrons rather than a moving pointer, for the reason that an electrón beam can sweep across the picture very rapidly indeed. The other dif-ference involves merely the use of a screen which glows momentarily when the electrons hit, rather than a chemically treated paper or film which is permanently altered. This speed is necessary in televisión, for motion pictures rather than stills are the object.

Use chemically treated film in place of the glowing screen, allow the apparatus to transmit one picture only rather than a succession, and a rapid camera for dry photography results. The treated film needs to be far faster in action than pre-sent examples, but it probably could be. More serious is the objection that this scheme would involve putting the film inside a vacuum chamber, for electrón beams behave normally only in such a rarefied environment. This difficulty could be avoided by allowing the electrón beam to play on one side of a partition, and by pressing the film against the other side, if this partition were such as to allow the electrons to go through perpendicular to its surface, and to prevent them from spreading out sideways. Such partitions, in crude form, could certainly be constructed, and they will hardly hold up the general development.

Like dry photography, microphotography still has a long way to go. The basic scheme of reducing the size of the record, and examining it by projection rather than directly, has possibilities too great to be ignored. The combination of optical projection and photographic reduction is already producing some results in microfilm for scholarly purposes, and the potentialities are highly sug-gestive. Today, with microfilm, reductions by a linear factor of 20 can be employed and still produce full clarity when the material is re-enlarged for ex-amination. The limits are set by the graininess of the film, the excellence of the optical system, and the efficiency of the light sources employed. All of these are rapidly improvmg.

Assume a linear ratio of 100 for future use. Consider film of the same thickness as paper, although thinner film will certainly be usable. Even under these conditions there would be a total factor of 10,000 between the bulk of the ordi-nary record on books and its microfilm replica.

The *Encyclopaedia Britannica* could be reduced to the volume of a matchbox. A library of a million volumes could be compressed into one end of a desk. If the human race has produced since the invention of movable type a total record, in the form of magazines, newspapers, books, tracts, advertising blurbs, correspondence, having a volume corresponding to a billion books, the whole affair, assembled and compressed, could be lugged offin a moving van. Mere compression, of course, is not enougl one needs not only to make and store a record but also be able to consult it, and this aspect of the matter comes laten Even the modern great library is not gener-ally consulted; it is nibbled at by a few.

Compression is important, however, when it comes to costs. The material for the microfilm *Britannica* would cost a nickel, and it could be mailed anywhere for a cent. What would it cost to print a million copies? To print a sheet of newspaper, in a large edition, costs a small fraction of a cent. The entire material of the *Britannica* in reduced microfilm form would go on a sheet eight and one-half by eleven inches. Once it is available, with the photographic reproduction mediods of the fiíture, duplicates in large quantities could probably be turned out for a cent apiece beyond the cost of materials. The preparation of the original copy? That introduces the next aspect of the subject.

To make the record, we now push a pencil or tap a typewriter. Then comes the process of digestión and correction, followed by an intricate process of typeset-ting, printing, and distribution. To consider the first stage of the procedure, will the author of the future cease writing by hand or typewriter and talk directly to the record? He does so indirectly, by talking to a stenographer or a wax cylinder: but the elements are all present if he wishes to have his talk directly produce a typed record. All he needs to do is to take advantage of existing mechanisms and to alter his language.

At a recent World Fair a machine called a Voder was shown. A girl.stroked its keys and it emitted recognizable speech. No human vocal chords entered into the procedure at any point; the keys simply combined some electrically produced vi-brations and passed these on to a loud-speaker. In the Bell Laboratories there is the converse of this machine, called a Vocoder. The loudspeaker is replaced by a microphone, which picks up sound. Speak to it, and the corresponding keys move. This may be one element of the postulated system.

The other element is found in the stenotype, that somewhat disconcerting device encountered usually at public meetings. A girl strokes its keys languidly and looks about the room and sometimes at the speaker with a disquieting gaze. From it emerges a typed strip which records in a phonetically simplified language a record of what the speaker is supposed to have said. Later this strip is re-typed into ordinary language, for in its nascent form it is intelligible only to the

¡nitiated. Combine these two elements, let the Vocoder run the stenotype, and the result is a machine which types when talked to.

Our present languages are not especially adapted to this sort of mechaniza-tion, it is true. It is strange that the inventors of universal languages have not seized upon die idea of producing one which better fitted the technique for trans-tnitting and recording speech. Mechanization may yet forcé the issue, especially ¡n the scientific field; whereupon scientific jargon would become still less intel-iigible to the layman.

One can now picture a íiiture investigator in his laboratory. His hands are free. md he is not anchored. As he moves about and observes, he photographs and :omments. Time is automatically recorded to tie the two records together. If he goes into the field, he may be connected by radio to his recorder. As he pondera Dver his notes in the evening, he again talks his comments into the record. His typed record, as well as his photographs, may both be in miniature, so that he projects them for examination.

Much needs to occur, however, between the collection of data and observa-tions, the extraction of parallel material from the existing record, and the final in-sertion of new material into the general body of the common record. For mature thought there is no mechanical substitute. But creative thought and essentially repetitive thought are very different things. For the latter there are, and may be. powerful mechanical aids.

Adding a column of figures is a repetitive thought process, and it was long ago properly relegated to the machine. True, the machine is sometimes controlled by i keyboard, and thought of a sort enters in reading the figures and poking the cor-responding keys, but even this is avoidable. Machines have been made which will read typed figures by photocells and then depress the corresponding keys; these iré combinations of photocells for scanning the type, electric circuits for sorting the consequent variations, and relay circuits for interpreting the result into the ac-tion of solenoids to pulí the keys down.

All this complication is needed because of the clumsy way in which we have learned to write figures. If we recorded them positionally, simply by the configuration of a set of dots on a card, the automatic reading mechanism would become comparatively simple. In fact if the dots are boles, we have the) unched-card machine long ago produced by Hollorith for the purposes of the •ensus, and now used throughout business. Some types of complex businesses ould hardly opérate without these machines.

Adding is only one operation. To perform arithmetical computation involves iso subtraction, multiplication. and división, and in addition snmp tnptbnH fnr temporary storage of results, removal from storage for further manipulation, a« recording of final results by printing. Machines for these purposes are now of tw« types: keyboard machines for accounting and the like, manually controlled for tr.e insertion of data, and usually automatically controlled as far as the sequence o operations is concerned; and punched-card machines in which sepárate oper tions are usually delegated to a series of machines, and the cards then transferret bodily from one to another. Botli forms are very useful; but as far as complex < putations are concerned, both are still in embryo.

Rapid eléctrica! counting appeared soon after the physicists found it desir to count cosmic rays. For their own purposes the physicists promptly constructi thermionic-tube equipment capable of counting electrical impulses at the rate« 100,000 a second. The advanced arithmetical machines of the future wül electrical in nature, and they will perform at 100 times present speeds, or me

Moreover, they will be far more versatile than present commercial macr so that they may readily be adapted for a wide variety of operations. They will 1 controlled by a control card or film, they will select their own data and manij: late it in accordance with the instructions thus inserted, they will perform < plex arithmetical computations at exceedingly high speeds, and they wül i results in such form as to be readily available for distribution or for later i manipulation. Such machines will have enormous appetites. One of their. take instructions and data from a whole roomful of girls armed with simple 1 board^ punches, and will deliver sheets of computed results every few mi ir- rhere will always be plenty of things to compute in the detailed affairs of millicaf people doing complicated things.

The repetitive processes of thought are not confined, however, to matters arithmetic and statistics. In fact, every time one combines and records facts in ac cordance with established logical processes, the creative aspect of thinkin¿ . concerned only with the selection of the data and the process to be employed **an** the manipulation thereafter is repetitive in nature and hence a fit matter to be egated to the machine. Not so much has been done along these lines, beyond bounds of arithmetic, as might be done, primarily because of the economics the situation. The needs of business and the extensive market obviously waiti assured the advent of mass-produced arithmetical machines just as soon as duction methods were sufficiently advanced.

With machines for advanced analysis no such situation existed; for there was and is no extensive market; the users of advanced methods of manipulating data iré a very small part of the population. There are, however, machines for solving differential equations—and functional and integral equations, for that matter. There are many special machines, such as the harmonic synthesizer which predicts the tides. There will be many more, appearing certainly first in the hands of the scientist and in small numbers.

If scientific reasoning were limited to the logical processes of arithmetic, we should not get far in our understanding of the physical world. One might as well attempt to grasp the game of poker entirely by the use of the mathematics of probability. The abacus, with its beads strung on parallel wires, led the Arabs to positional numeration and the concept of zero many centuries before the rest of the world; and it was a useful tool—so useful that it still exists.

It is a far cry from the abacus to the modern keyboard accounting machine. It will be an equal step to the arithmetical machine of the future. But even this new machine will not take the scientist where he needs to go. Relief must be secured from laborious detailed manipulation of higher mathematics as well, if the users of it are to free their brains for something more than repetitive detailed transformations in accordance with established rules. A mathematician is not a man who can readily manipulate figures; often he cannot. He is not even a man who can readily perform the transformations of equations by the use of calculus. He is primarily an individual who is skilled in the use of symbolic logic on a high plane, and especially he is a man of intuitive judgment in the choice of the manipulative processes he employs.

All else he should be able to turn over to his mechanism, just as confidently as he turns over the propelling of his car to the intricate mechanism under the hood. Only then will mathematics be practically effective in bringing the growing knowledge of atomistics to the useful solution of the advanced problems of chemistry, metallurgy, and biology. For this reason there still come more machines to handle advanced mathematics for the scientist. Some of them will be sufficiently bizarre to suit the most fastidious connoisseur of the present arti-facts of civilization.

The scientist, however, is not the only person who manipúlales data and examines the world about him by the use of logical processes, although he sometimes

preserves this appearance by adopting into the fold anyone who becomes logical, much in the manner in which a British labor leader is elevated to knighthood Whenever logical processes of thought are employed—that is, whenever though for a time runs along an accepted groove—there is an opportunity for the machine. Formal logic used to be a keen instrument in the hands of the teacher u bis trying of students' souls. It is readily possible to construct a machine whid will manipúlate premises in accordance with formal logic, simply by the eleve use of relay circuits. Put a set of premises into such a device and turn the cranl and it will readily pass out conclusión after conclusión, all in accordance with lo{| ical law, and with no more slips than would be expected of a keyboard adding nú chine.

Logic can become enormously difíicult, and it would undoubtedly be well t produce more assurance in its use. The machines for higher analysis have usially been equation solvers. Ideas are beginning to appear for equation tramformers, which will rearrange the relationship expressed by an equation i accordance with strict and rather advanced logic. Progress is inhibited by the aceedingly crude way in which mathematicians express their relationships. The employ a symbolism which grew like Topsy and has little consistency; a stranj fact in that most logical field.

A new symbolism, probably positional, must apparently precede the redui tion of mathematical transformations to machine processes. Then, on beyond ti strict logic of the mathematician, lies the application of logic in everyday affair We may some day click off arguments on a machine with the same assuran» that we now enter sales on a cash register. But the machine of logic will not lo(like a cash register, even of the streamlined model.

So much for the manipulation of ideas and their insertion into the recor Thus far we seem to be worse off than befo re—for we can enormously extend d record; yet even in its present bulk we can hardly consult it. This is a much larg matter than merely the extraction of data for the purposes of scientific researc it involves the entire process by which man profits by his inheritance of acquin knowledge. The prime action of use is selection, and here we are halting indee There may be millioris of fine thoughts, and the account of the experience (which they are based, all encased within stone walls of acceptable architectuí form; but if the scholar can get at only one a week by diligent search, his syntt ses are not likely to keep up with the current scene.

Selection, in this broad sense, is a stone adze in the hands of a cabinetmak Yet, in a narrow sense and in other áreas, something has already been done ra chanícallv on selection. The nersonnel officer of a factorv droos a stack of a fi

thousand employee cards into a selecting machine, sets a code in accordance with an established convention, and produces in a short time a list of all em-ployees who live in Trenton and know Spanish. Even such devices are much too slow when it comes, for example, to matching a set of fingerprints with one of five million on file. Selection devices of this sort will soon be speeded up from their present rate of reviewing data at a few hundred a minute. By the use of photocells and microfilm they will survey ítems at the rate of a thousand a second, and will print out duplicates of those selected.

This process, however, is simple selection: it proceeds by examining in turn every one of a large set of ítems, and by picking out those which have certain spec-ified characteristics. There is another form of selection best illustrated by the au-tomatic telephone exchange. You dial a number and the machine selects and connects just one of a million possible stations. It does not run over them all. It pays attention only to a class given by a first digit, then only to a subclass of this given by the second digit, and so on; and thus proceeds rapidly and almost un-erringly to the selected station. It requires a few seconds to make the selection, although the process could be speeded up if increased speed were economically warranted. If necessary, it could be made extremely fast by substituting thermionic-tube switching for mechanical switching, so that the full selection could be made in one one-hundredth of a second. No one would wish to spend the money necessary to make this change in the telephone system, but the general idea is applicable elsewhere.

Take the prosaic problem of the great department store. Every time a charge sale is made, there are a number of things to be done. The inventory needs to be revised, the salesman needs to be given credit for the sale, the general accounts need an entry, and, most important, the customer needs to be charged. A central records device has been developed in which much of this work is done conve-niently. The salesman places on a stand the customer's identification card, his own card, and the card taken from the article sold—all punched cards. When he pulís a lever, contacts are made through the holes, machinery at a central poinl makes the necessary computations and entries, and the proper receipt is printed for the salesman to pass to the customer.

But there may be ten thousand charge customers doing business with the store, and before the full operation can be completed someone has to select the ight card and inserí it at the central office. Now rapid selection can slide jusl he proper card into position in an instant or two, and return it afterward. An->ther difficulty occurs, however. Someone must read a total on the card, so thal he machine can add its computed ítem to it. Conceivably the cards might be OÍ the dry photography type I have described. Existing totals could then be read by photocell, and the new total entered by an electrón beam.

The cards may be in miniature, so that they occupy little space. They must move quickly. They need not be transferred far, but merely into position so that die photocell and recorder can opérate on them. Positional dots can enter the data. At the end of the month a machine can readily be made to read these and to print an ordinary bilí. With tube selection, in which no mechanical parts are involved in the switches, little time need be occupied in bringing the correct card into use—a second should suffice for the entire operation. The whole record on the card may be made by magnetic dots on a steel sheet if desired, instead of dots to be observad optically, following the scheme by which Poulsen long ago put speech on a magnetic wire. This method has the advantage of simplicity and ease of erasure. By using photography, however, one can arrange to project the record in enlarged form and at a distance by using the process common in televisión equipment.

One can consider rapid selection of this form, and distant projection foi other purposes. To be able to key one sheet of a million before an operator in a second or two, with the possibility of then adding notes thereto, is suggestive in many ways. It might even be of use in libraries, but that is another story. At any rate, there are now some interesting combinations possible. One might, for **ex**ample, speak to a microphone, in the manner described in connecüon with the speech-controlled typewriter, and thus make his selections. It would certainlj beat the usual file clerk.

The real heart of the matter of selection, however, goes deeper dian a lag in the adoption of mechanisms by libraries, or a lack of development of devices foi their use. Our ineptitude in getting at the record is largely caused by the artificiality of systems of indexing. When data of any sort are placed in storage, they are filed alphabetically or numerically, and information is found (when it is) by tracing it down from subclass to subclass. It can be in only one place, unless duplicates are used; one has to have rules as to which path will lócate it, and the rules are cumbersome. Having found one Ítem, moreover, one has to emerge from the system and re-enter on a new path.

The human mind does not work that way. It opérales by association. **With** one Ítem in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain. It has other characteristics, of course; trails that are not fre-quently followed are prone to fade, Ítems are not fully permanent, memory is transitory. Yet the speed of action, the intricacy of trails, the detail of mental pic-tures, is awe-inspiring beyond all else in nature.

Man cannot hope fully to duplícate this mental process artificially, but he certainly ought to be able to learn from it. In minor ways he may even improve, for his records have relative permanency. The first idea, however, to be drawn from the analogy concerns selection. Selection by association, rather than in-dexing, may yet be mechanized. One cannot hope thus to equal the speed and flexibility with which the mind follows an associative trail, but it should be pos-sible to beat the mind decisively in regard to the permanence and clarity of the Ítems resurrected from storage.

Consider a future device for individual use, which is a sort of mechanized prívate file and library. It needs a ñame, and, to coin one at random, "memex" wül do. A memex is a device in which an individual stores all his books, records, and Communications, and which is mechanized so that it may be consulted with ex-ceeding speed and flexibility. It is an enlarged intímate supplement to his memory.

It consists of a desk, and while it can presumably be operated from a distance, it is primarily the piece of furniture at which he works. On the top are slanting translucent screens, on which material can be projected for convenient reading. There is a keyboard, and sets of buttons and levers. Otherwise it looks like an or-dinary desk.

In one end is the stored material. The matter of bulk is well taken care of by improved microfilm. Only a small part of the interior of the memex is devoted to storage, the rest to mechanism. Yet if the user inserted 5,000 pages of material a day it would take him hundreds of years to fill the repository, so he can be proflígate and enter material freely.

Most of the memex contents are purchased on microfilm ready for insertion. Books of all sorts, pictures, current periodicals, newspapers, are thus obtained and dropped into place. Business correspondence takes the same path. And there is provisión for direct entry. On the top of the memex is a transparent platen. On this are placed longhand notes, photographs, memoranda, all sorts oí things. When one is in place, the depression of a lever causes it to be pho--ographed onto the next blank space in a section of the memex film, dry plio-.ography being employed.

There is, of course, provisión for consultation of the record bv the usual scheme of indexing. If the user wishes to consult a certain book, he taps its code an the keyboard, and the title page of the book promptly appears before him, projected onto one of his viewing positions. Frequently used codes are mnemonic, so that he seldom consults his code book; but when he does, a single tap of a key projects it for his use. Moreover, he has supplemental levers. On deflecting one of these levers to the right he runs through the book before him, each page in turn being projected at a speed which just allows a recognizing glance at each. If he deflects it further to the right, he steps through the book 10 pages at a time; still further at 100 pages at a time. Deflection to the left gives him the same control backwards.

A special button transfers him irnmediately to the first page of the Índex. *Any* given book of his library can thus be called up and consulted with far greater facility than if it were taken from a shelf. As he has several projection positions, he can leave one Ítem in position while he calis up ariother. He can add marginal notes and comments, taking advantage of one possible type of dry photography and it could even be arranged so that he can do this by a stylus scheme, such aa is now employed in the telautograph seen in railroad waiting rooms, just as though he had the physical page before him.

All this is conventional, except for the projection forward of present-day mechanisms and gadgetry. It affords an immediate step, however, to associative indexing, the basic idea of which is a provisión whereby any Ítem may be causee at will to select irnmediately and automatically another. This is the essential fea ture of the memex. The process of tying two iteras together is the importan thing.

When the user is building a trail, he ñames it, inserís the ñame in his cod< book, and taps it out on his keyboard. Before him are the two Ítems to be joined projected onto adjacent viewing positions. At the bottom of each there are ¡ number of blank code spaces, and a pointer is set to indicate one of these on eacl itera. The user taps a single key, and the Ítems are permanently joined. In eacl code space appears the code word. Out of view, but also in the code space, is in serted a set of dots for photocell viewing; and on each ítem these dots by their po sitions desígnate the Índex number of the other Ítem.

Thereafter, at any time, when one of these ítems is in view, the other can b mstanrlv recalled merelv bv taDDÍne: a button below the corresponding cod

space. Moreover, when numerous Ítems have been thus joined together to form i trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical Ítems bad been gathered together from widely separated sources and bound together to form a new book. It is more than this, for any Ítem can bejoined into numerous trails.

The owner of the memex, let us say, is interested in the origin and properties of the bow and arrow. Specifically he is studying why the short Turkish bow was apparently superior to the English long bow in the skirmishes of the Crusades. He has dozens of possibly pertinent books and articles in his memex. First he runs through an encyclopedia, finds an interesting but sketchy article, leaves it projected. Next, in a history, he finds another pertinent Ítem, and ties the two together. Thus he goes, building a trail of many Ítems. Occasionally he inserís a comment of his own, either linking it into the main trail or joining it by a side trail to a particular item. When it becomes evident that the elastic properties of avail-able materials had a great deal to do with the bow, he branches off on a side trail which takes him through textbooks on elasticity and tables of physical constants. He inserís a page of longhand analysis of his own. Thus he builds a trail of his interest through the maze of materials available to him.

And his Irails do not fade. Several years later, his talk with a friend turns to the queer ways in which a people resist innovations, even of vital interest. He has an example, in the fact that the outraged Europeans still failed to adopt the Turkish bow. In fact he has a trail on it. A touch brings up the code book. Tapping a few keys projects the head of the trail. A lever runs through it at will, stopping at interesting Ítems, going off on side excursions. It is an interesting trail, pertinent to the discussion. So he sets a reproducer in action, photographs the whole trail out, and passes it to his friend for insertion in his own memex, there to be linked into the more general trail.

8

Wholly new forms of encyclopedias will appear, ready made with a mesh of as-sociative trails running through them, ready to be dropped into the memex and there amplified. The lawyer has at his touch the associated opinions and deci-sions of his whole experience, and of the experience of friends and authorities. The patent attorney has on cali the millions of issued patents, with familiar trails to everv ooint of his client's interest. The nhvsician. nuzzled bv a natient's reactions, strikes the trail established in studying an earlier similar case, and runs rapidly through analogous case histories, with side references to the classics for the pertinent anatomy and histology. The chemist, struggling with the synthesis oían organic compound, has all the chemical literature before him in his labo-ratory, with trails following the analogies of compounds, and side trails to their physical and chemical behavior.

The historian, with a vast chronological account of a people, parallels it with a skip trail which stops only on the salient Ítems, and can follow at any time con-temporary trails which lead him all over civilization at a particular epoch. There is a new profession of trail blazers, those who find delight in the task of estab-lishing useful trails through the enormous mass of the common record. The in-heritance from the master becomes not only his additions to the world's record, but for his disciples the entire scaffolding by which they were erected.

Thus science may implement the ways in which man produces, stores, and consults the record of the race. It might be striking to outline the instrumentali-ties of the future more spectacularly, rather than to stick closely to methods and elements now known and undergoing rapid development, as has been done here. Technical difficulties of all sorts have been ignored, certainly, but also ignored are means as yet unknown which may come any day to accelerate technical progress as violently as did the advent of the thermionic tube. In order that the picture ma> not be too commonplace, by reason of sticking to present-day patterns, it may be well to mention one such possibility, not to prophecy but merely to suggest, foi prophecy based on extensión of the known has substance, while prophec) founded on the unknown is only a doubly involved guess. All our steps in creat-ing or absorbing material of the record proceed through one of the senses—thí tactile when we touch keys, the oral when we speak or listen, the visual when wt read. Is it not possible that some day the path may be established more direcdy:

We *know that when the eye sees,* all the consequent information is transmit-ted to die brain by means of electrical vibrations in the channel of the optic nerve. This is an exact analogy with the electrical vibrations which occur in the cable of a televisión set: they convey the picture from the photocells which see it to the radio transmitter from which it is broadcast. We know further that if we can ap-proach that cable with the proper instruments, we do not need to touch it; we can pick up those vibrations by electrical induction and thus discover and reproduce the scene which is being transmittedjust as a telephone wire may be tapped foi its message.

The impulses which flow in the arm nerves of a typist convey to her fingers the translated information which reaches her eye or ear, in order that the fingers may be caused to strike the proper keys. Might not these currents be intercepted, either in the original form in which Information is conveyed to the brain, or in the marvelously metamorphosed form in which they then proceed to the hand?

By bone conduction we already introduce sounds: into the nerve channels of the deaf in order that they may hear. Is it not possible that we may learn to introduce them without the present cumbersomeness of first transiórming electri-cal vibrations to mechanical ones, which the human mechanism promptly transforms back to the electrical form? With a couple of electrodes on the skull the encephalograph now produces pen-and-ink traces which bear some relation to the electrical phenomena going on in the brain itself. True, the record is un-intelligible, except as it points out cei tain gross misfunctioning of the cerebral mechanism; but who would now place bounds on where such a thing may lead?

In the outside world, all forms of intelligence, whether of sound or sight, have been reduced to the form oí varying currents in an electric circuit in order that they may be transmitted. Inside the human frame exactly the same sort of process occurs. Must we always transform to mechanical movements in order to proceed from one electrical phenomenon to another? It is a suggestive thought, but it hardly warrants prediction without losing touch with reality and immedi-ateness.

Presumably man's spirit should be elevated if he can better review his shady past and analyze more completely and objectively his present problems. He has built a civilization so complex that he needs to mechanize his records more fully if he is to push his experiment to its logical conclusión and not merely become bogged down part way there by overtaxing his limited memory. His excursions may be more enjoyable if he can reacquire the privilege of forgetting the manifold things he does not need to have immediately at hand, with some assurance that he can find them again if they prove important.

The applications of science have built man a well-supplied house, and are teaching him to live healthily therein. They have enabled him to throw masses o) people against one another with cruel weapons. They may yet allow him truly to encompass the great record and to grow in the wisdom of race experience. He may perish in conflict before he learns to wield that record for his truc good. Yet. in the application of science to the needs and desires of man, it would seem to be a singularly unfortunate stage at which to terminate the process, or to lose hope as to the outcome.

Tea Nelson

Computer Lib/ Dream Machines (1974)

COMPUTER LIB

dream machines

Ted Nelson,* Computer Lib/Dream Machines. © *TedNelson. Courtesy ofTedNelson.

"Everythíng /s deeply ¡ntertw'mgled.

« Ted Nelson describes himself as a person who invents paradigms and then makes up words to express them. Nelson had little formal training in computer science. However, as a gradúate student in philosophy in the late 1950s and sarly 1960s, Nelson had two critical ¡ntellectual encounters that led him to become one of the most influential figures ¡n computing. One was with Vannevar Bush's article "As We May Think," which convinced Nelson that emerging information technologies could extend the power of human memory. The second was with Samuel Taylor Coleridge's poem "Xanadu," "a magic place of literary memory/' in Nelson's words, that provided him with the image of a vast storehouse of memories, and which served as the inspiration for his life's work. From these influences, Nelson began his quest to build creative tools that would transform the way we read and write, and ¡n 1963 he coined the words ftypertexí and *hypermedia* to describe the new paradigms that these tools would make possible.

In 1974, he self-published his landmark tome on personal computing, *Computer Lib/Dream Machines,* which instantly drew an underground following of computer hackers, media theorists, and experimental artists. The oversized volume had a playful, do-it-yourself quality, with typesetting done by typewriter, distinc-tive hand-drawn illustrations, and *a* layout that suggested the nonlinear nature of hypermedia. Written with the author's trademark droll humor, the book ¡s a stream-of-consciousness, randomly generated sequence of bombastic truths and speculations, a patchworklike Journal that covers everything from hardware sys-tems and new art forms to the decline of western civilization. Nelson was par-ticularly concerned with the complex nature of the creative impulse, and he saw the computer as the tool that would make explicit the ¡nterdependence of ideas, drawing out connections between literature, art; music, and science, since, as he put ¡t, everything ¡s "deeply mtertwingled."

Nelson's critical breakthrough was to cali for a system of nonsequential writing that would allow the reader to aggregate meaning in snippets ("lexias," as Roland Barthes defined them), in the order of his or her choosing, rather than according to a preestablished structure fixed by the author. Nelson's visión for a new form of interactive literature was a hybrid concept that married Vannevar Bush's notion of a memory bank organized around associative links with Douglas Engelbart's research ¡n human-computer ¡nterface and the augmentaron of human intellect. It was from this conceptual framework that he drew his ambitious plans for a global repository of cultural ¡nformation, Xanadu. Intended to become the ideal new publishing system for the digital age, this visionary design was later eclipsed by Tim Berners-Lee's invention of the World Wide Web ¡n **1989. »**

the tissue of thought

Uneducated people typically think of education as the learning of a lot of facts and skills. While facts and skills certainly have their merits, "higher education" is also largely concerned with tying ideas together, and especially alternative structures of such tying-together: with showing you the vast uncertainties of things.

A wonderfuljapanese film of the fifties was called *Rasho-Mon.* It depicted a specific event—a rape—as told by five different people. As the audience watches the five separate stories, they must try to judge what *really* happened.

The Rasho-Mon Principle: everything is like that. The complete truth about something is never known.

Nobody tells the complete truth, though some try. Nobody knows the complete truth. Nowhere may we find *printed* the complete truth. There are only different views, assertions, supposed facts that support one view or another but are disputed by disbelievers in the particular views; and so on. There are "agreed-on facts," but their *meaning* is often in doubt.

The great compromise of the western world is that we go by the rule: *assume* that we never know the final truth about anything, There are continuing Issues, Mysteries, Continuing Dialogues. What about flying saucers, "why Rome fell," was there a Passover Plot, and Did Roosevelt know Pearl Harbor would be attacked?

Outsiders find the intellectual world pompous, vague in its undecided issues, stuffy in its quotes and citations. But in a way these are the sounds of battle. The clash of theories is what many find exhilarating about the intellectual world. The Scholarly Arena is simply a Circus Maximus in which these battles are scheduled.

Many people think "science" is free from all this. These are people who do not know much about science. More and more is scientifically known, true; but it is repeatedly discovered that some scientific "knowledge" is untrue, and this problem is built into the system. The important thing about science is not that everything will be known, or that everything unanimously believed by scientists is necessarily true, but that science contains a *system* for seeking untruth and purging it.

This is the great tradition of western civilization. The Western World is, in an important sense. a continuing dialogue among people who have thought different things. "Scholarship" is the tradidon of tiying to improve, collate and resolve uncertainties. The fundamental ground rules are that no issue is eveí closed, no interconnection is impossible. It all comes down to *what is written,* because the thoughts and minds themselves, of course, do not last. (The appa-ratus of citation and footnote are simply a combination of hat-tipping, go-look-if-you-don't-believe-me, andyou-might-want-to-read-this-yourself.)

"Knowledge," then — and indeed most of our civilization and what remains oi those previous— is a vasty cross-tangle of ideas and evidential materials, not a pyramid of truth. So that preserving its structure, and improving its accessibil-ity, is important to us all.
Which is one reason we need hypertexts and thinkertoys.

Psychology
Philosophy

Movie-making Whatevet-

Presentational Sequences Are Arbitrary

Hierarchies Are Typically Spurious

|LANGUAGE
TRUTH

Boundaries of Fields Are Arbitrary

Sociology

Compartmentalized and Stratified Teaching Produces Compartmentalized and Stratified Minds.

the heritage

The past is like the receding view out the back of an automobile: the most recent is more conspicuous, and everything seems eventually to be lost.

We know we could save things, but what? Those with the *Job* of saving things—the libraries and museums—save so many of the wrong things, the fash-lonable and expensive and high-toned things esteemed by a given time, and most *íf* the rest slips past. Each generation seems to ridicule the things held in esteem by times before, but of course this can never be a guide to what *should* be saved. And there is so much to save: music, writing, sinking Venice, vanishing species.

But why should things be saved? Everything is deeply intertwingled. We save for knowledge and nostalgia, but what we thought was knowledge often turns to nostalgia, and nostalgia often brings us deeper insights that cut across our lives and very selves.

Computers offer an interesting daydream: that we may be able to store things *digitally* instead *ofpkysically.* In other words, turn the libraries to digital storage; digitize paintings and photographs; even digitize the genetic codes of animáis, so that species can be restored at future dates.

Digital storage possesses several special advantages. Digitally stored materials may be copied by automatic means; corrective measures are possible, to prevent errors from creeping in—i.e., "no deterioration" in principie; and they could be kept in various places, lessening mankind's dependence on its eggs being all in one basket (like the Library at Alexandria, whose burning during the occupation of Julius Caesar was one of the greatest losses in human history).

But this would of course require far more compact and reliable forms of digital storage than exist right now.

Nevertheless, we better start thinking about it. Those who fear a coming holocaust had best think about pulling some part of mankind through, with some part of what he used to have.

hypermedia

In recent years a very basic change has occurred in presentational systems of all kinds. We may summarize it under the ñame *branching,* although there are many variants. Essentially, today's systems for presenting pictures, texts and whatnot can bring you different things automatically depending on what you do. Selec-tion of this type is generally called *branching.* (I have suggested the generic term *hypermedia* for presentational media which perform in this (and other) multidi-mensional ways.)

A number of branching media exist or are possible.
Branching *movies* or hyperfilms (see nearby).
Branching *texts* or hypertexts (see nearby).

Branching audio, music, etc.
Branching slide-shows.
Wish we could get into some of that stuff here.

hypertext

By "hypertext" I mean non-sequential writing.

Ordinary writing is sequential for two reasons. First, it grew out of speech and speech-making, which have to be sequential; and second, because books are not convenient to read except in a sequence.

But *the structures of ideas* are not sequential. They tie together every which-way. And when we write, we are always trying to tie things together in non-sequential ways. *Thefootnote* is a break from sequence; but it cannot really be extended (though some, like Will Cuppy, have toyed with the technique).

I have run into perhaps a dozen people who understood this instantly when I talked to them about it. Most people, however, act more bemused, thinking Pin trying to tell them something technical or pointlessly philosophical. It's not pointless at all: the point is, writers do better if they don't have to *write* in sequence (but may créate múltiple structures, branches and alternatives), and read-ers do better if they don't have to *read* in sequence, but may establish impressions, jump around, and try different pathways until they find the ones they want to study most closely.

(The astute reader, and anybody who's gotten to this point must be, will have noticed that this book is in "magazine" layout, organized visually by ideas and meanings, for that precise reason. I will be interested to hear whether that has worked.)

And the pity of it is that (like the man in the French play who was surprised to learn that he had been "speaking prose all his life and never known it"), we've been speaking *hypertext* all our lives and never known it.

Now, many writers have *tried* to break away from sequence. I think of Nabokov's *Palé Fire,* of *Tristram Shandy* and an odd novel of Julio Cortázar called *Hopscotch,* made up of sections ending with numbers telling you where you can branch to. There are many more; and large books generally use many tricks to get around the problem of indexing and reviewing what has and hasn't been said or done already.

However, in my view, a new day is dawning. Computer storage and screen display mean that we no longer *have* to have things in sequence; totally arbitrary structures are possible, and I think that after we've tried them enough people will see how desirable they are.

types of hypertext

Let's assume that you have a high-power display—and storage displays *won't do.* because you have to see things *move* in order to understand where they come from and what they mean. (Especially text.) So it has to be a refreshed CRT.

Basic or chunk style hypertext offers choices, either as footnote-markers (like asterisks) or labels at the end of a chunk. Whatever you point at then comes to the screen.

Collateral hypertext means compound annotations or parallel text.

Stretchtext changes *continuously.* This requires very unusual techniques, but exemplifies how "continuous" hypertext might work.

Ideally, chunk and continuous and collateral hypertext could all be combined (and in turn collaterally linked).

A "fresh" or "specific" hypertext—I don't have a better term at the moment—would consist of material especially written for some purpose. An *anthological* hypertext, however, would consist of malcriáis brought together from all over, like an anthological book.

A *grana hypertext,* then, folks, would be a hypertext consisting of "everything" written about a subject, or vaguely relevant to it, tied together by editors (and NOT by "programmers," dammit), in which you may read *in all the directionsyou wish to pursue.* There can be alternative pathways for people who think different ways. People who *have* to have one thing explained to them at a time— many have insisted to me that this is normal, although I contend that it is a patho-logical condition—may have that; others, learning like truc human beings, may gather and sift impressions until the ideas become clear.

And then, of course, you see the real dream.

The real dream is for "everything" to be in the hypertext.

Everything you read, you read from the screen (and can always get back to right away); everything you write, you write at the screen (and can cross-link te whatever you read).

Paper moulders. Microfilm is inconvenient. In the best librarles it takes ai least minutes to get a particular thing. But as to linking them together—footnoting Aeschylus with Marcus Aurelius, linking genetic data to 15th-century ac

^ounts of Indian tribes—well, you can only do it on paper by writing something *new* that ties them together. Isn't that ridiculous? When you could do it all electronically in seconds?

Now that we *have* all these wonderful devices, it should be the goal of society to put them in the service of truth and learning. And this is the way I propose. *Not* through obscure forms of "information retrieval"; *not* through newly oppressive forms of "computer-assisted instruction;" and *not* through a purported science of "artificial intelligence" that will créate new personalisms to irk us. All these obstructive oddities, I think, have developed as sepárate ideáis because of the grand preposterosity of Professionalism that has created a world-wide cult of mutual incomprehensibility and disconnected special goals. Now we need to get everybody together again. We want to go back to the roots of our civilization— the ability, which we once had, for everybody who could read to be able to read everything. We *musí* once again become a community of common access to a shared heritage.

This was of course what Vannevar Bush said in 1945, in an article everybody cites but nobody reads.

The hypertext solution in many ways obviates some of these other approaches, and in addition retains and puts back together the great traditions of literature and scholarship, traditions based on the fact that dividing things up ar-bitrarily just generally doesn't work.

the burning bush

In fact hypertexts were foreseen very clearly in 1945 by Vannevar Bush, Roosevelt's science advisor. When the war was in the bag, he published a little article on various groovy things that had become possible by that time.

"As We May Think" *(Atlantic Monthly,* July 1945) is most notable for itf clear description of various hypertext techniques—that is, linkages between doc uments which may be brought rapidly to the screen according to their linkages (So what if he thought they'd be on microfilm.)

How characteristic of Professionalism. Bush's article has been taken as thi starting point for the field of Information Retrieval, but its actual contents haví been ignored by acclamation. Information Retrieval folk have mostly done ver different things, yet thought they were in the tradition.

Now people are "rediscovering" the article. If there's another edition of thi hnnk T Vione T can run it in entiretv.

doug engelbart and "the augmentation of intellect"

Douglas Engelbart is a saintly man at Stanford Research Institute whose dream has been to make people smarter and bring them together. His system, on which millions of dollars have been spent, is a wonder and a glory.

He began as an engineer of CRTs; but his driving thought was, quite correctly, that these remarkable objects could be used to expand man's mind and improve each shining hour.

Doug Engelbart's visión has never been restricted to narrow technical issues. From the beginning his concern was not merely to plank people down at display consoles, but in the most profound sense to expand man's mind. "The Augmentation of Human Intellect," he calis it, by which he means making minds work better by giving them better tools to work with.

An obvious example is writing: before people could write things down, men could only learn what they experienced or were told by others in person; writing changed all that. Within the computer-screen fraternity, the next step is obvious; screens can double and redouble our intellectual capacities. But this is not obvious to everybody. Engelbart, patiently instructing those outside, carne up with a beautiíul example. To show what he meant by the Augmentation of Intellect, Engelbart *tiedapencil to a brick.* Then he actually made someone write with it. The result, which was of course dreadful, Engelbart solemnly put into a published report. Not yet being able to demónstrate the augmentation of intellect, since he had as yet no system to show off, he had masteríully demonstrated the dt'saugmentation of intellect: what happens if you make man's tools for working out his thoughts *worse* instead of better. As this poor guy was with his brickified pencil, explained Engelbart, so are we all among our bothersome, inflexible systems of paper.

Starting small, Engelbart programmed up a small versión of what most fans cali "The Engelbart System" some ten years ago. One versión has it that when it carne to looking for grants, management thought he acted too kooky, and so assigned a Front Man to make the presentation. But, as the story goes, the man from ARPA pointed at Engelbart and said, "We want to back *him."*

A small but dedicated group at SRI has built up a system from scratch. First they used little CDC 1700 minicomputers; then, various grants later, they were able to set up their own PDP-10, in which the system now resides, and from which it reaches out across the country.

Doug calis his system NLS, or "oN-Line System." Basically it is a highly responsive, deeply-structured text system, feeding out to display termináis. From a terminal you may read anything you or others have written, and write with as-yet-unmatched flexibility.

The display termináis are all over. The project has gone national, though at great expense: through the ARPA net of computers, you can in principie become a user of NLS for something like $50,000 a year.

mouse?

The Engelbart Folks have built a pointing device, for telling the system where you're pointing on the screen, that is considerably faster and handier than a light-pen. (Unfortunately, I don't believe it's commercially available.) It's called The Mouse.

The Engelbart Mouse is a little box with hidden wheels underneath and a cable to the terminal. As you roll it, the wheel's turns are signalled to the computer and the computer moves the cursor on the screen. *Ifsfast and accurate,* and in fact beats a lightpen hands down in working speed.

Through the command language, NLS allows users to créate programs that respond in all sorts of ways; thus the fact that certain texthandling styles are standard results more from tradition than necessity.

The same apparently is truc of the data structure. I used to be somewhat dis-turbed at the way Engelbart's text systems seem to be rigorously hierarchical. This in fact is the case, in the sense that having múltiple discrete levéis is built deep into the system. But it turns out to be harmless. The stored text is divided by the storage techniques into múltiple levéis, corresponding to a Harvard out-line. Think of it as something like this:

1. HIERARCHICAL FORMAT
A. STORAGE
B. DISPLAY
C. LANGUAGE

But let's expand this example a little:

1. HIERARCHICAL FORMAT A. STORAGE
AI. Everything in NLS is stored with hierarchical codes. A2. Their effect depends on the display.

B.DISPLAY

BI. The hierarchical codes of NLS have no consequences in *partit
ular.* B2. The hierarchical codes for NLS can splay the material out into;
variety of display arrangements. B2A. They can be displayed in outline form. B2B. They can be displayed in normal text form. B2C. These dratted numbers can even be made to disappear.

C.LANGUAGE

CI. The command language determines what the display shows a
the hierarchical structure. C2. *What* is shown can be determined by a program in the commanc
language. (For instance, "how many levéis down" it is beinj
shown).
C2A. This is four levéis down. (The earlier example wasn't.)
C3. The display format all depends on what display program you
use, in the NLS command language.

That's enough of that. I can't help remarking that I still don't like that sort oí structuring, but it is deep in NLS, and if you don't like it either (poor deprived lucky user of NLS) you can program it to disappear, so it's hardly in your way.

by the beard of the prophet!

Engelbart in Germán means Angelbeard; Doug Engelbart is indeed on the side of the angels. In building his mighty system he points a new way for humanity. The sooner the better. Any history of the twentieth century will certainly hold him high. Few great men are also such nice guys.

A very basic hypertext system

Hypertext is non-sequential writing. It's no good to us, though, unless we can go instantly in a choice of directions from a given point.

This of course can only mean on computer display screens.

Engelbart's system, now, was mainly designed for people who wanted to immerse themselves in it and learn its conventions. Indeed, it might be said to have been designad for a community of people in cióse contact, a sort of system of blackboards and collaborative talking papers.

A more elemental system, with a difíerent slant, was put together at Brown U. on IBM equipment. We'll refer to it here as "Carmody's System," after the young programmer whose ñame carne first on the writeup.

Carmody's system runs on an IBM 360 with 2250 display. While the 2250 is a fine piece of equipment, the quirks of the 360's operating system often delay the user by making him wait, e.g., for someone else's cards to get punched before it re-sponds to bis more immediate uses; this is like making ice-skaters wait for oxcarts.

Anyway, the system essentially imposes no structure on the material; it may consist of text segments of any length and ties and links between them. An as-terisk appearing anywhere in one piece of text signáis a possible jump, but the reader doesn't necessarily know where to; sapping the asterisk with the lightpen takes you there, however.

This is stark and simple. It could also get you good and lost. However, a simple technique took care of that: every time the user jumped, the address of his previous location was saved on a *stack.* The user also had a RETURN button: when he wanted to go back to where he had last jumped from, the system would pop the last address off the top of the stack, and take him there. (This feature was adapted from my 1967 Stretchtext paper, and turned out to work out quite well in practice.)

The system also had handy features for light-pen text editing, and variou nice printout techniques. All told, it was a clean and powerful design. While i lacked higher-level visualization facilities, like Engelbart's display of Levéis or collateral display, it was in some ways suited for naive users; that is, it was eventu-ally fairly safe to use, and could in large part be taught to rank beginners in ¡ couple of hours—provided they didn't have to know about JCL cards.

It is left for the reader to figure out interesting uses for it. How would you de collateral structures? How could you signal to a reader which of several piece! of text ajump was to?

(At least one real hypertext was actually written on this system. It tied togethei a lot of patents for multilayer eíectrodes. Readers agreed that they could lean *more from it about multilayer eíectrodes than they had imagined wanting to* know.)

Man Kay and Adele boldberg

Personal Dynamic Media" (1977)

17

Dynabook. Gourtesy o/Alan Kay.

'magine having your own self-contained knowledge nanipuiator ¡n a portable package the size and shape ofan irdinary notebook. Suppose it had enough power to outrace 'our senses ofsight and hearing/ enough capacity to store ·or later retríeval thousands of page-equivalents of reference vaterials, poems, letters, recipes, records, drawings, mmatlons, musical scores, waveforms, dynamic úmulations, and anyth'mg e/se you would like to remember indchange."

174 Alan Kay and Adele Goldberg

« Alan Kay's goal for the Learning Research Group he founded at Xerox PAR(¡n the early 1970s was no less than to ¡nvent the future of communication, anl the knowledge tools to make ¡t possible.This article ¡s condensed from a PAR(technical report that documents the six years of research behind the first work able hypermedia system.Together with his assistant Adele Goldberg, Kay outlina the génesis of Smalltalk, an object-oriented software language that led to the in vention of the graphical user ¡nterface.Their research took root ¡n the convictiol that hypermedia, or "dynamic media," as they cal led ¡t, represented a profoum departure from static media such as painting, televisión, photography, print pub lishing, and film. They saw in hypermedia the radical interactivity that wouk characterize Communications in the future.

The prototype that was the focus of Kay and Goldberg's research, the Dyna book, was conceived as a "dynamic médium for creative thought," capable o synthesizing all media—pictures, animation, sound, and text—through the ¡ntí macy and responsiveness of the personal computer. The Dynabook was, in part an interpretation of Vannevar Bush's information storage device, the memex. I incorporated the navigational conventions of Douglas Engelbart's oNLine Sys tem (the mouse, Windows, and menus in particular). It also borrowed from TeJ Nelson's concept of hypermedia. While Kay and his team never built the proto type of the Dynabook, by 1974 its key ideas were incorporated into the Xeroj Alto computer running the Smalltalk operating system. As a result, the Alto i< regarded as the first personal computer, and the original desktop multimedia sys tem.

The Dynabook was meant for everyone, enabling people of all ages to discova and express their creativity. It included software such as a text editor, an an¡ mation system, a paint program, and music scoring systems. It was, as the ai| thors describe it, a "metamedium," containing within ¡t all other media. TN Dynabook also brought together divergent media through a single interface making desktop hypermedia a reality.To prove the accessibility of the device, chil dren were recruited to test the prototype machine, and to write original softwar< applications such as music and painting programs. Kay's work carne to the at tention of young entrepreneurs ¡n the computer industry, ¡ncluding Steve Jobs o

Apple Computer and Bill Gates of Microsoft, who profited enormously from tW powerful operating system that was designed to give free reign to the intuitivi mechanisms of achild's mind. »

NTRODUCTION

"he Learning Research Group at Xerox Palo Alto Research Center is concerned dth all aspects of the communication and manipulation of knowledge. We de-¡gn, build, and use dynamic media which can be used by human beings of all ges. Several years ago, we crystallized our dreams into a design idea for a per-Dnal dynamic médium the size of a notebook (the *Dynabook)* which could be wned by everyone and could have the power to handle virtually all of its owner's iformation-related needs. Towards this goal we have designed and built a com-lunications system: the Smalltalk language, implemented on small computers we ífer to as "interim Dynabooks." We are exploring the use of this system as a pro-ramming and problem solving tool; as an interactive memory for the storage and lanipulation of data; as a text editor; and as a médium for expression through rawing, painting, animating pictures, and composing and generating music.

We offer this paper as a perspective on our goals and activities during the past ears. In it, we explain the Dynabook idea, and describe a variety of systems we ave already written in the Smalltalk language in order to give broad images of the inds of information-related tools that might represent the kernel of a personal omputing médium.

jackground

lumans and media. "Devices" which variously store, retrieve, or manipúlate in->rmation in the form of messages embedded in a médium have been in existence >r thousands of years. People use them to communicate ideas and feelings both) oüiers and back to themselves. Although thinking goes on in one's head, ex-:rnal media serve to materialize thoughts and, through feedback, to augment the :tual paths the thinking follows. Methods discovered in one médium provide letaphors which contribute new ways to think about notions in other media.

For most of recorded history, the interactions of humans with their media ave been primarily nonconversational and passive in the sense that marks on aper, paint on walls, even "motion" pictures and televisión, do not change in re-x>nse to the viewer's wishes. A mathematical formulation—which may sym-olize the essence of an entire universe—once put down on paper, remains static id requires the reader to expand its possibilities.

Every message is, in one sense or another, a *simulation* of some idea. It may be representational or abstract. The essence of a médium is very much dependen! on the way messages are embedded, changed, and viewed. Although digital com-puters were originally designed to do arithmetic computation, the ability to simúlate the details of any descriptive model means that the computer, viewed as a médium itself, can be *all other media* if the embedding and viewing methods are sufficiendy well provided. Moreover, this new "metamedium" is *active*—it can re-spond to queries and experiments—so that the messages may involve the learnei in a two-way conversation. This property has never been available before excepl through the médium of an individual teacher. We think the implications are vasl and compelling.

A dynamic médium for creative thought: the Dynabook. Imagine having your own self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook. Suppose it had enough power to outrace your senses of sight and hearing, enough capacity to store for later retrieval thou-sands of page-equivalents of reference materials, poems, letters, recipes, records, drawings, animations, musical scores, waveforms, dynamic simulations, and any-thing else you would like to remember and change.

We envision a device as small and portable as possible which could both take in and give out information in quantities approaching that of human sensory systems. Visual output should be, at the least, of higher quality than what can be obtained from newsprint. Audio output should adhere to similar high-fidelit)i standards.

There should be no discernible pause between cause and effect. One of the metaphors we used when designing such a system was that of a musical instru-ment, such as a ilute, which is owned by its user and responds instandy and con-sistently to its owner's wishes. Imagine the absurdity of a one-second déla) between blowing a note and hearing it!

These "civilized" desires for flexibility, resolution, and response lead to the conclusión that a user of a dynamic personal médium needs several hundred times as much power as the average adult now typically enjoys from timeshared computing. This means that we should either build a new resource several hundred times the capacity of current machines and share it (very difficult and ex-pensive), or we should investígate the possibility of giving each person his owi powerful machine. We chose the second approach.

Design background. The first attempt at designing this metamedium (die FLE> machine) occurred in 1967-69. Much of the hardware and software was suc cessíul from the standpoint of computer science state-of-the-art research, bu¡

Iked sufficient expressive power to be useful to an ordinary user. At that time e became interested in focusing on children as our "user community." We were reatly encouraged by the Bolt Beranek and Newman/MIT Logo work that uses i robot turtle that draws on paper, a CRT versión of the turtle, and a single music
;enerator to get kids to program.

Considering children as the users radiales a compelling excitement when iewed from a number of different perspectives. First, the children really can vrite programs that do serious things. Their programs use symbols to stand for ibjects, contain loops and recursions, require a fair amount of visualization of al-ernative strategies before a tactic is chosen, and involve interactive discovery ind removal of "bugs" in their ideas.

Second, the kids love it! The interactive nature of the dialogue, the fact that *hey* are in control, the feeling that they are doing *real* things rather than playing mh toys or working out "assigned" problems, the pictorial and auditory nature >f their results, all contribute to a tremendous sense of accomplishment to their xperience. Their attention spans are measured in hours rather than minutes.

Another interesting nugget was that children really needed as much or more omputing power than adults were willing to settle for when using a timesharing vstem. The best that timesharing has to offer is slow control of crude wire-frame jeen-tinted graphics and square-wave musical tones. The kids, on the other tand, are used to finger-paints, water colors, color televisión, real musical intruments, and records. If the "médium is the message," then the message of 3w-bandwidth timesharing is "blah."

V.\ interim dynabook

\e have designed an interim versión of the Dynabook on which several intersting systems have been written in a new médium for communication, the mañulk\jTO<^m\am^Im<^^ vith more than 200 users, most notably setting up a learning resource center in i local júnior high school.

The interim Dynabook is a completely self-contained system. To the user, it ippears as a small box in which a disk memory can be inserted; each disk con-ains about 1500 page-equivalents of manipulable storage. The box is connected o a very crisp high-resolution black and white CRT or a lower-resolution high-[uality color display. Other input devices include a typewriter keyboard, a chord" keyboard, a pointing device called a "mouse" which inputs position as

it is moved about on the table, and a variety of organ-like keyboards for playiil music. New input devices such as these may be easily attached, usually withoi building a hardware interface for them. Visual output is through the display. ai ditory output is obtained from a built-in digital-to-analog converter connected I a standard hi-fi amplifier and speakers.

We will attempt to show some of the kinds of things that can be done with Dynabook; a number of systems developed by various users will be briefly illu trated.

Remembering, seeing and hearing. The Dynabook can be used as an intera tive memory or file cabinet. The owner's context can be entered through a ke board and active editor, retained and modified indefinitely, and displayed o demand in a font of publishing quality.

Drawing and painting can also be done using a pointing device and an icón editor which allows easy modification of pictures. A picture is thus a manipul ble object and can be animated dynamicaüy by the Dynabook's owner.

A book can be read through the Dynabook. It need not be treated as a sina lated paper book since this is a new médium with new properties. A dynam search may be made for a particular context. The non-sequential nature of the **fi** médium and the use of dynamic manipulation allows a story to have many a cessible points of view; Durrell's *Alexandria Quartet,* for instance, could be oí book in which the reader may pursue many paths through the narrative.

Different fonts for different effects. One of the goals of the Dynabook's desij is *not* to be *worse* than paper in any important way. Computer displays of the pa have been superior in matters of dynamic writing and erasure, but have failed contrast, resolution, or case of viewing. There is more to the problem than ju the display of text in a high-quality font. Different fonts créate different moa and cast an aura that influences the subjective style of both writing and readin The Dynabook is supplied with a number of fonts which are contained on the £ storage.

The Dynabook as a personal médium is flexible to the point of allowing ¡ owner to choose his own ways to view information. Any character font can be d scribed as a matrix of black and white dots. The owner can draw in a charad font of his own choosing. He can then immediately view font changes within ti context of text displayed in a window. With the Dynabook's fine grain of dispt the rough edges disappear at normal viewing distance to produce high-quali characters.

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iditing. Every description or object in the Dynabook can be displayed and ídited. Text, both sequential and structured, can easily be manipulated by combining pointing and a simple "menú" for commands, thus allowing deletion, ransposition, and structuring. Múltiple windows allow a document (composed >f text, pictures, musical notation) to be created and viewed simultaneously at ¡everal levéis of refinement. Editing operations on other viewable objects (such is pictures and fonts) are handled in analogous ways.

Filing. The multiple-window display capability of Smalltalk has inspired the lotion of a dynamic *document.* A document is a collection of objects that have a ¡ensory display and have something to do with each other; it is a way to store and •etrieve related information. Each subpart of the document, or *frame,* has its >wn editor which is automatically invoked when pointed at by the "mouse." Fhese frames may be related sequentially, as with ordinary paper usage, or *in-•erted* with respect to properties, as in cross-indexed file systems. *Sets* which an automatically map their contents to secondary storage with the ability to brm unions, negations, and intersections are part of this system, as is a "mode-ess" text editor with automatic right justification.

The current versión of the system is able to automatically cross-file several housand multifield records (with formáis chosen by the user), which include orlinary lexlual documenls indexed by contení, the Smalltalk system, personal ¡les. diagrams, and so on.

)rawing/painting. The many small dots required to display high-qualily charcters (about 500,000 for an 8-1/2" X 11" sized display) also allow skelching-uality drawing, "halftone painting," and animation. The subjective effecl of gray cale is caused by the eye fusing an área containing a mixture of small black and .'hite dots. A brush can be grabbed with ihe "mouse," dipped into a paint pol, **nd** then the halftone can be swabbed on as a funclion of ihe size, shape, and ve->city of the brush.

Curves are drawn by a *pen* on the display screen. (Straight lines are curves iih zero curvature.) In the Dynabook, *pens* are members of a class that can se-rctively draw with black or white (or colored) ink and change ihe ihickness of le irace. Each *pen* lives in its own *window,* careful not to traverse its window oundaries but to adjust as its window changes size and position.

Jiimation and music. Animation, music, and programming can be thoughl of ; different *sensory views* of dynamic processes. The structural similarities among them are apparent in Smalltalk, which provides a common framework for es pressing those ideas.

All of the systems are equally controllable by hand or by program. Thiu drawing and painting can be done using a pointing device or in conjunclia with programs which draw curves, fill in áreas with tone, show perspectives (three-dimensional models, and so on. Any graphic expression can be animatec either by reflecting a simulation or by example (giving an "animator" program sample trace or a route to follow).

Music is controlled in a conipletely analogous manner. The Dynabook can a< as a "super synthesizer" getting direction either from a keyboard or from "score." The keystrokes can be captured, edited, and played back. Timbres, di "fonts" of musical expression, contain the quality and mood which different ir struments bring to an orchestration. They may be captured, edited, and used namically.

simulation

In a very real sense, simulation is the central notion of the Dynabook. Each of ti previous examples has shown a simulation of visual or auditory media. Here ai a number of examples of interesting simulations done by a variety of users.

An animation system programmed by animators. Several professíonal anima tors wanted to be able to draw and paint pictures which could then be animal» in real time by simply showing the system roughly what was wanted. Desireí changes would be made by iconically editing the animation sequences.

Much of the design of SHAZAM, their animation tool, is an automation of th media with which animators are familiar: *movies* consisting of sequences c *frames* which are a composition of transparent *cels* containing foreground ani background drawings. Besides retaining these basic concepts of convention: animation, SHAZAM incorporales some creative supplementary capabilities. Animators know thal ihe main aclion of animation is due not to an individ ual frame, but to the change from one frame to the next. It is therefore much eaí ier lo plan an animalion if it can be seen moving as it is being crealed. SHAZAÍ allows any cel of any frame in an animation to be edited while ihe animalion is i progress. A library of already-crealed cels is maintained. The animation can b single-stepped; individual cels can be reposilioned, reframed, and redrawn; nei frames can be insertad; and a frame sequence can be created at any time by al

ling the cel to the pointing device, then *showing* the system what kind of vement is desired. The cels can be stacked for background parallax; *hales* d *windows* are made with *transparent* paint. Animation objects can be painted programs as well as by hand. The control of the animation can also be easily)ne from a Smalltalk simulation. For example, an animation of objects bouncig in a room is most easily accomplished by a few lines of Smalltalk that express ic class of bouncing objects in physical terms.

L drawing and painting **system programmed by a child.** One young girl, who iad never programmed before, decided that a pointing device *ought* to let her Iraw on the screen. She then built a sketching tool without ever seeing ours. She onstantly embellished it with new features including a menú for brushes se-2Cted by pointing. She later wrote a program for building tangram designs.

This girl has taught her own Smalltalk class; her students were seventh-raders from her júnior high school. One of them designed an even more elaboate system in which pictures are constructed out of geometric shapes created by ointing to a menú of commands for creating regular polygons. The polygons can nen be relocated, scaled, and copied; their color and line width can change.

ai audio animation system programmed by musicians. Animation can be onsidered to be the coordinated parallel control through time of images coneived by an animator. Likewise, a system for representing and controlling muical images can be imagined which has very strong analogies to the visual world. lusic is the design and control of images (pitch and duration changes) which can e *painted* diñerent *colors* (timbre choices)-, it has synchronization and coordi-ation, and a very cióse relationship between audio and spatial visualization.

The Smalltalk model created by several musicians, called TWANG, has the otion of a *chorus* which contains the main control directions for an overall piece. I chorus is a kind of *rug* with a warp of parallel sequences of "pitch, duration, nd articulation" commands, and a woof of synchronizations and global direc-.ves. The control and the *player* are sepárate: in SHAZAM, a given movie se-|uence can animate many drawings; in TWANG, a given chorus can tell many lifferent kinds of instrumentalists what should be played. These *voices* can be ynthetic timbres or timbres captured from real instruments. Musical effects such s vibrato, portamento, and diminuation are also available.

A chorus can be *drawn* using the pointing device, or it can be *captured* by ilaying it on a keyboard. It can be played back in real time and dynamically dited in a manner very similar to the animation system.

We use two methods for real-time production of high-quality timbres; bo allow arbitrary transients and many independent parallel voices, and are coi pletely produced by programs. One of these allows independent dynamic co trol of the spectrum, the frequency, the amplitude, and the particular collecti< of partíais which will be heard.

For children, this facility has a number of benefits: the strong similarities I tween the audio and visual worlds are emphasized because a single vernacul *which actually works* in both worlds is used for description; and second, the ai and skills of composing can be learned at the same time since tunes may drawn in by hand and played by the system. A line of music may be copit stretched, and shifted in time and pitch; individual notes may be edited. Imi tive counterpoint is thus easily created by the íledgling composer.

A musical score capture system programmed by a musician. OPUS is a u sical score capture system that produces a display of a conventional musii score from data obtained by playing a musical keyboard. OPUS is designed allow incremental input of an arbitrarily complicated score (full orchestra wi chorus, for example), editing pages of the score, and hard copy of the final res with sepárate parts for individual instruments.

conclusión

What would happen in a world in which everyone had a Dynabook? If such a n chine were designed in a way that *any* owner could mold and channel its pow to his own needs, then a new kmd of médium would have been created metamedium, whose contení would be a wide range of already-existing and rt yet-invented media.

An architect might wish to simúlate three-dimensional space in order to pen and edit his current designs, which could be conveniently stored and ero referenced.

A doctor could have on file all of his patients, his business records, a di reaction system, and so on, all of which could travel with him wherever went.

A composer could hear his composition while it was in progress, partícula if it were more complex than he was able to play. He could also bypass the credibly tedious chore of redoing the score and producing the parts by hand

Learning to play music could be aided by being able to capture and hear one's own attempts and compare them against expert renditions. The ability to express music in visual terms which could be filed and played means that the acts of composition and self-evaluation could be learned without having to wáit for tech-nical skill in playing.

Home records, accounts, budgets, recipes, reminders, and so forth, could be easily captured and manipulated.

Those in business could have an active briefcase which travelled with them, containing a working simulation of their company, the last severa! weeks of correspondence in a structured cross-indexed form—a way to instantly calcúlate profiles for their íiitures and help make decisions.

For educators, the Dynabook could be a new world limited only by their imagination and ingenuity. They could use it to show complex historical interrelationships in ways not possible with static linear books. Mathematics could be-come a living language in which children could cause exciting things to happen. Láboratory experiments and simulations too expensive or difficult to prepare could easily be demonstrated. The production of stylish prose and poetry could be greatly aided by being able to easily edit and file orie's own compositions.

Tliese arejust a few ways in which we envision using a Dynabook. But if the pro¡ected audience is to be "everyone," is it possible to make the Dynabook gener-illy useful, or will it collapse under the weight of trying to be too many different tools for too many people? The total range of possible users is so great that any ittempt to specifically anticípate their needs in the design of the Dynabook would *znd* in a disastrous feature-laden hodgepodge which would not be really suitable Por anyone.

Some mass Ítems, such as cars and televisión sets, attempt to anticipate and provide for a variety of applications in a fairly inflexible way; those who wish to do something different will have to put in considerable eífort. Other Ítems, such is paper and clay, offer many dimensions of possibility and high resolution; these :an be used in an unanticipated way by many, though *tools* need to be made or Dbtained to stir some of the medium's possibilities while constraining others.

We would like the Dynabook to have the flexibility and generality of this second kind of Ítem, combined with tools which have the power of the first kind. Thus i great deal of effort has been put into providing both endless possibilities and :asy tool-making through the Smalltalk programming language.

Our design strategy, then, divides the problem. The burden of system desigí and specification is transferred to the user. This approach will only work if we di a very careful and comprehensive Job of providing a general médium of cora munication which will allow ordinary users to casually and easily describe thei desires for a specific tool. We must also provide enough already-written genera tools so that a user need not start from scratch for most things she or he may wisl to do.

We have stated several specific goals. In summary, they are:

3. to provide coherent, powerful examples of the use of the Dynabook in an across subject áreas;
4. to study how the Dynabook can be used to help expand a person's visu¡ and auditory skills;
5. to provide exceptional freedom of access so kids can spend a lot of tini probing for details, searching for a personal key to understanding processithey use daily; and
6. to study the unanticipated use of the Dynabook and Smalltalk by childrein all age groups.

Richard A. Bolt

"Spatial Data-Management" (1979)

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system

Spatial Data-Management. Courtesy ofHans-Christian Lischewski.

" *We have attempted to créate an interface which ¡s not a tiny, narrow-band ^port-hole'into an Information bank, that bank ¡tselfan abstractly addressedset of intangibles. Rather, we have attempted radically to recast the setting as an ^{y}mformational surround' wherein the user ¡s dírectly engaged with data bodied forth in visión, sound, and touch, data inhabiting a spatially defínite Virtual' world that can be interactively explored and navigated."*

186 Richard A. Bolt

« Richard Bolt is one of the most influential figures ¡n the field of multimodj ¡nterfaces—interfaces that enable the user to interact with a computer throug manual gesture and speech, rather than a keyboard and mouse. In the 1970s h was a member of the Architecture Machine Group at MIT, the precursor to til Media Lab and a center for many of the technological breakthroughs and cor ceptual paradigms that define human-computer interface. At Arch-M AC, as tíj center was called, Bolt designed the legendary "media room" under the directia ofhis cióse collaborator Nicholas Negroponte.The "media room" placed the us(in an environment that was itself a computer interface that reacted to voice, ge ture, and gaze.The user sat in a chair, pointed at objects that appeared on a wa| sized screen, and spoke commands that moved computer-generated objects 1 specified locations. They called ¡t the "Put-That-There" system. Bolt continué this research as a founding member of the Media Lab, heading its Advance Human Interface Group.

While heralded for "Put-That-There," Bolt and Negroponte are less knovn for the work represented in this groundbreaking paper from the same pericn which describes the "media roomV'spatial data-management system, or SDM5 This was the first hypermedia system to organize information for retrieval withi a 3-D virtual environment—to offer, in Bolt's words, "a multidimensional wii dow into data." SDMS took a significantly different approach to hypermedi than the one pursued by Vannevar Bush,Ted Nelson, and Douglas Engelbart, wh had conceived of it as a way to link media objects to one another through a Índex. Alan Kay continued in this tradition when he introduced the GUI, wh¡< used icons arranged on a fíat "desktop" surface to represent bodies of inform, tion. SDMS, however, drew on developments ¡n virtual reality, which led Bolt ar Negroponte to consider how data might be presented as symbols within an q gaging, multisensory, navigable environment.

The premise was simple. As Bolt writes, the "well-evolved human ability 1 organize information spatially remains essentially untapped in the realm < computer-based information handling." SDMS relied on what Bolt called "til Simonides Effect." Simonides, the ancient Greek poet famous for his memor would divide his poems into parts, and learn each at a different location in a ten ple.To recall the text, he would visualize himself walking through the temple *an* the parts would come back to him in sequence. Bolt and Negroponte used th "ancient principie of using spatial cueing as an aid to performance and memory as a model for the information landscape they developed for SDMS, which trw referred to as"Dataland." Significantly, the SDMS allowed usersto make not« of their observations as they pursued their own trails of association through th

system.The Dataland was not only navigable, it could be interacted with. A half decade before William Gibson popularized theconcept of "cyberspace/' Boltand Negroponte had built a working prototype that gave the user the freedom to explore and engage with an architecturally conceived hypermedia environment.»

the concept

The basis of spatial data-management is accessing a data Ítem by going to where it is rather than referencing it by ñame.

Consider what occurs when you retrieve a book in your home library. You look at the left-hand bookcase, second shelf from the top, say, and sean about two-thirds down the shelf for a certain book spine, Thus, the book is located not by its title but by its customary site in a space defined by other books and the bookcase itself.

Consider how people ordinarily find Ítems on their desktops: the appointment book is up and to the right; the telephone is in the lower right córner; high priority memos are kept in an "in" box immediately to the left of the desk blot-ter; less urgent Ítems are in the file folder, top middle of desk; and so forth.

The person who uses this desk has organized the layout of Ítems in a more or less systematic way. He or she refers to them constantly throughout the working day: reaching in that direction, that far, up, down, to the right, to the left. Through this activiry, a mental image of the layout of the desk is elaborated in the "mind's eye." Additionally, through constant tactile interaction with the Ítems, reaching for and touching them, a "motor memory" of where things are arises as well. A script for the act of retrieval becomes encoded into the musculature, as it were, according to where the Ítem is located.

The practical importance of this spatial principie of organization is illustrated when someone happens to disturb our familiar arrangement of things. Perhaps some well-meaning soul tries to tidy up our seemingly chaotic desktop. Rather than being a benefit, the now "well-organized" desk is for us an organi-zational disaster: the former "messy" arrangement was a familiar and well trav-eled ground whereupon we could go directly to what we wanted. Such a loss of a familiar spatial layout can impress upon us the extent to which we take this sub-tle but poweríul principie of organization for granted in our daily lives.

An even more striking instance of the role of spatiality in common experience is the coherence and persistence of "imagery." Two individuáis, arguing a topic in front of a blackboard, will refer each other to diagrams, equations, and terms on the basis of where they had been written, even long after they have been erased!

It is surprising how pervasive the underlying notion of spatiality is, even i] symbolic modes of thought. Consider a file of three-by-five notecards, organiza alphabetically, but without letter tabs showing. "Filed under the letter *R" traía* lates into a tactile estimate of how far down the row of cards we must reach. Th same holds truc for a dictionary without thumb indexes. When we want to loo! up a word beginning with the letter .ñ, we "guesstimate" where we should opa the pages of the book to begin our search. Thus, *R* is somehow a relative distanc* as well as a letter. There is more spatiality implicit in what is ordinarily thougk oías symbolic retrieval than we may realize.

In summary, it is precisely the insight about how we tend to retrieve itera from desktops, from files and bookshelves, even from erased blackboards, that lie at the heart of the spatial data management concept: we find Ítems on the basi of a more or less defmite sense of their location in a familiar space, which spac may be actually present or remembered.

This well-evolved human ability to organize information spatially remains *a* sentially untapped in the realm of computer-based information handling. Typ cally, in such systems, retrieval on a symbolic or ñame basis is the norm, and mu¡ be the norm because the conventional keyboard interface is too limited a chai nel, the wrong mode and médium, to begin to offer the user a direct, palpabl sense of spatiality.

In the spring of 1976, the Architecture Machine Group at MIT proposed I the Cybernetics Technology Office of the United States Defense Advanced Ri search Projects Agency (DARPA) a program of research organized under ti title "Augmentation of Human Resources in Command and Control throug Múltiple Media Man-Machine Interaction." Intrinsic to the ensemble of studu outlined in the proposal was a study recalling the ancient principie of using sp¡ tial cueing as an aid to performance and memory: the "Simonides Effect."

Simonides was a poet of ancient Greece famous for bis ability to give Ion recitations entirely from memory. His secret, which as a teacher of rhetoric 1 shared with his students, was to tie each successive part of a to-be-remembere poem or speech to a specific lócale within the mental floor plan of either an actual or imagined temple. Around the floor of the temple were statues, serving I augment the imagery of specific niches or corners.

To commit to memory a long poem or speech, the orator would pause in h imagination before the threshold, and with this mental image in mind, commit ti introductory remarks to memory. Then, for each successive subsection of the ta to be given, the orator would mentally walk from place to place within the tei pie, rehearsing the appropriate material before some specific piece of statuai

The resultant path about the temple would then serve as a mental *schema* to organize the speech upon its eventual recitation, the speech being retrieved and reconstructed during oration by way of an imaginary tour from statue to statue around the temple floor.

Another study outlined in that same proposal looked to the exploitation of *virtual spatiality* as a matrix for organizing information: the "virtual bulletin board." This term refers to the formulation of an implicit space which occupies no "real" space but can nonetheless contain a great deal, as well as offer the same spatial organizational cueing as to the whereabouts of material that real work surfaces do. The tacit size of a "field" of information to be portrayed in computer graphics need not be limited by the size of the physical display. Since it is virtual, its apparent size and graphic organization are open to user definition in the unconstrained sense of Ivan Sutherland's characterization of a computer display as "a window on Alice's Wonderland" ("Computer *Displays" Scientific American,* June 1970).

These two spatial themes specifically resonated with Dr. Craig Fields, Sénior Program Manager in the Cybernetics Technology Office. As a result we started to explore the potentialities of a spatially oriented data management system, "a multidimensional window into data." The outcome has been that over the past two years, under the aegis of DARPA, the Architecture Machine Group has been experimenting with the creation of an information-management system whose distinguishing characteristic is that it exploits the user's sense of spatiality for purposes of organizing and retrieving data: a spatial data-management system, or SDMS.

the setting

The setting of our experimental versión of SDMS is a múltiple media information place. It can be construed as an image of an office of the future.

The physical aspects of our "media room" are easily described. The media room is about the size of a personal office. The focal point of the room is a wall-sized display screen. Directly in front of this large screen is an instrumented Eames chair. On either arm of the chair is a small, pressure-sensitive "joystick." A.djacent to the joystick on each arm is a two-inch-square touch-sensitive pad. \lso associated with the chair as complementary instrumentation is a ten-inch-iquare data tablet, with stylus; the tablet is upholstered to serve as a lap pad. This ablet bears added instrumentation: a small microphone mounted at its top edge o allow voice input.

Two small televisión monitors are situated one on either side of the chair.

Each of these monitors is touch-sensitive so that the user can point to data or can input gestures indicating actions to be taken.

Finally, eight loudspeakers provide sound output for the media room. Four of them are placed around the perimeter of the large-format display to the users front. The remaining four are correspondingly arrayed to the user's rear. Octa-phonic sounds can be presented to the user as coming from various apparent di-rections in the space of the room, in coordination with actions on the visual display. The rate of playback is variable so that dynamic sound/motion effects. such as Doppler shifts, may be achieved. We cali these "sound-synch graphics."

Notice that there is a conspicuous, but not mandatory, absence of a keyboard.

The configuration described is one which evolved through previous work for the Office of Naval Research (Contract number 0014-75-C-0460) and over the course of our experimentation, but this precise ensemble is certainly not the only one that might have been adopted. The kernel notion of managing data spatially is not necessarily tied to a room-sized terminal into which a user goes versus a desktop arrangement in front of which he or she sits.

The relaxed ambiance conveyed by the presence of a chair of the Eames genre in lieu of something more utilitarian is intentional, however. It reflects convictions and positions about the nature and tone of human-computer interaction that we have attempted to actualize in the media room setting. Just as the hands-on immediacy of touch-sensitive pads suggests a literal impatience with intangibles about data, so the decor as epitomized in the selection of the style of chair rebuts the premise that system users must live in severe, ascetic settings.

We have attempted to créate an interface which is not a tiny, narrow-band "port-hole" into an information bank, that bank itself an abstractly addressed set of intangibles. Rather, we have attempted radically to recast the setting as an "in-formational surround" wherein the user is directly engaged with data bodied forth in visión, sound, and touch, data inhabiting a spatially definite "virtual" world that can be interactively explorad and navigated.

finding data

Spatial data-management involves the creation of a plausible and commodious "virtual" space at the computer interface, together with a way of getting around in that space quickly and easily.

The spatial world of SDMS consists of a single *plañe.* This surface, called "Dataland," is presented to the user in two aspects: (1) it is continuously visible

to the user in its entirety in an "aerial," top-on view displayed on one of the mon-itors, arbitrarily situated to the user's right, called the "world view" monitor; and (2) simultaneously, a small subsector of the Dataland surface is displayed on the ten-foot diagonal screen to the user's front, vastly enlarged and with appre-ciable gain in detail.

The logical relationship between these two views is akin to a mapping key, which places a particular image within a larger lócale. The large screen eííectively functions as a "window" and, as we shall see later, a "magnifying glass" onto Dataland.

The "world view" monitor serves specifically as a navigational aid to the user in getting around Dataland. The large display of whatever portion of Dataland is so "ciόse up" that the user would get lost easily if there were not always on view a map of the entire Dataland world. A small, highlighted, "you-are-here" rectan-gle on that display shows the user at all times the position of the large-screen window on Dataland.

To illustrate how an actual Dataland might appear to a user seated in the media room's control chair, let us assume a datábase already created. In practice, individuáis would design and structure their own Datalands according to personal preferences, tasks, and needs, just as the contents and organization of any-one's desktop come to reflect some combination of Job requirements and individual taste.

Now, what is visible to the user on the surface of this example of Dataland?

ítems of various sorts may be seen. Soine are small photographs: pictures of animáis, of people, even a miniature LANDSAT satellite photo of New England. Other Ítems look like small maps. We see what appear to be book covers, televisión sets, a business letter, even a small image of an electronic hand-held calculator. Yet other ítems resemble emblems or "glyphs," not dissimilar from business logos.

How does one get around in such an informational landscape?

User control of navigation around Dataland is provided by "joystick" action. The small joystick in the right arm of the chair permits a helicopter-like flight over the surface. The joystick itself does not deflect, but responda to pressure. It is "self-centering" in that it registers zero deflection when not touched. Push the stick "away" from you and the helicoptering motion over Dataland is north, or toward the top of the screen. Pulí the joystick toward you and motion is south. Pressure to the right and left will direct you east or west.

The apparent rate of travel is proportional to the pressure the user exerts on the joystick. At máximum pressure, it takes about twenty seconds to travel across Dataland. .

Perusing data

Logically distinct *{romfinding* a certain item in Dataland is *perusing* that item in place. Once the user has found the item and zoomed in on it, the specific forra that perusal takes is conditioned by the nature of the data.

In direct contrast to material that is "out there," visible, to be developed in íull simply by approach, are malcriáis which need to be "perused," where perusal means opening up a volume, starting a film clip, selecting part of a set of sudes to be seen, and so on. The essential idea is that the user opens up and develops his interchange with the data more or less interactively, through direct touch in a "hands-on" manner. The dictionary sense of "perusal" is that of "survey or scrutiny, in some thoroughness and detall." It is this *engaged* quality of person-data interchange that we intend by this terminology.

Our notion of perusal includes a class of "data types" which, when addressed, prove to be unusually rich in motion, color, and sound. One of these new data types is yet an oíd and familiar one: the "book."

The user zooms in on what appears from afar to be simply a rectangle. At cióse enough range, the color patch gains detail in the form of some horizontal black rows of "characters" implying a printed title. Upon even yet nearer approach, the black figures give way to readable text, giving the title of the item, which is now clearly seen as implying a "book-like" image.

The user, of course, knows that the rectangle is a "book," having put it therc in the first place. However, if he is a subscriber to a computer-network-based "book of the month" service, and has perhaps requested or has a standing ordei for books, the book may be one he has yet to see, having just appeared on the Dataland surface in a certain área on the data plañe serving as a "book drop" foi incoming Communications which are book-like.

Upon nearest approach, when the image of the book is fully addressed in thl visual sense of filling the large screen, a "table of contents" for the book appean on the second and so far unused color monitor to the user's left. This table-of contents view is one of a class of interactive "key maps" made available to the use as adjuncts to certain data types, to permit direct user interaction with the dac to be perused.

In this instance, the key map allows user access to the interior of the "book' on display, exactly as the table of contents of a "real" book lets the reader (a) knov what the book offers by way of topics covered, and (b) serves as a "dispatching[1] table to send the reader direcdy to the subsection of the book that is of most im-mediate interest.

The table of contents can "expand" to show a finer breakdown of contení área when the user selecls a major heading of interest. In concert with the activity on the key map monitor screen, the main large-screen view will "go to" the section of the book selected by the user through the interactive key map so that the user may read the material.

There is yet further interaction with the data type of the book: that of turning its pages. This action is initiated by a specific user action: a page-lurningges-*ture* given as right-to-left, top-to-bottom stroke on either of the touch-sensitive pads on the arms of the user chair. Any page can be turned back by a stroke across the pad in the opposite direction. The accompanying visual action is the display of an "animation" of a page actually turning. The upper right-hand córner of the page on view progressively "lifts" away and sweeps leftwards across the screen immediately revealing the new page below.

The intent is not to give a nostalgic impression of the way books used to look, like the electric fireplace with plástic back-lit logs. The purpose is quite functional. First, the page is a unit of apprehension of the book; it is a "bite-sized" chunk or packet of the material that one feels like one can take in com-fortably, in contrast to the stretching-ever-onward, rhythmless character of scrolled text. Second, the page serves as a progress marker through the text in a "milepost" sense. With continuous scrolling, such natural, discrete units of progress are not explicit in the médium, and, if felt necessary by the reader, must be efíbrtfuHy abstracted, resulting in a more burdensome tone to the reading task.

Thus, the "page-flipper" is not frivolous. It provides the user with feedback that a page has turned, the directionality of the animation corresponding to for-ward or backward. Specifically, it reinstales for the user, in the context of the reading of computer- televisión texl, ihe functional equivalen! of what *Üiefact* of the page gives to the reader of traditional paged printed media: the sense of knowing where you are in the material. More generally, it is an instance of whal we choose lo term a "media fiducial," a marking system, or buill-in fealure of any médium ihal serves ihe funclion of lelting you know "where you are" based on locational cues arising out of ihe basic structure of ihe médium itself.

One radical departure from the ordinary concept of the book, except as ad-umbraled in such page-corner flip-animalions as ihis reporl has in ils upper lefl-hand page corners, is the fact ihal while some page üluslralions will be still sudes, olher üluslralions will be "movies," or animaled diagrams, with or without sound

accompaniments. The possibility of sound can, upon occasion, pertnit the bo< to comment upon its own text and illustrations, and even read itself to you.

Another unusual data type residing in Dataland is that of televisión. An ii stance of this is the presence of a "glyph" on the Dataland surface which is ti image of a Sony televisión. Zoomed in on, the televisión set becomes very larg its own screen filling the large screen directly before the user. What is at first rather sketchy black-and-white image on the tube face of this "virtual televisión is then replaced with live action: *Columba, The Sting,* or a documentary on ha to stop smoking.

What may be seen on this televisión set in Dataland is anything that can I put on televisión, live or recorded, closed-circuit or broadcast. The user couk for example, indícate in the context of a session with SDMS that he next wan to view the twelve o'clock news, or see a rerun of some footage that was taped ea lier….

"Perusing" implies the scrutiny in detail of ítems. This scrutiny in detail a an interactive process surely will trigger in the user the impulse to annotate, to a¡ pendjottings, to comment "marginally." The traditional properties of compuU media typically frústrate this impulse, one so readily indulged in on papen

As an antidote to this shortcoming, we have introduced the capacity for mal ing written annotations in "transparent ink," of varying line widths and colon

The ink, because transparent, does not oblitérate material overwritten, and th notations made can be transient or permanent as the user wishes.

Notes and commentary can be not only in written form, but auditory as wd The user can employ the stylus and tablet to indícate an "anchorpoint" on th Dataland surface for to-be-recorded voice notes. The notes are played back sut sequently upon coming within some critical range of the site of the recording.

Sound can be itself a data type as well as a vehicle for annotations or navigj tional aid. An instance of sound as data in our initial SDMS prototype was digitally stored speech of Jerome Wiesner, Presiden! of MIT. A portion of thi speech was activated and played back upon approach to an image of Dr. Wiei ner, the volume increasing as one drew nearer by zooming in, or fading to the le or right as one withdrew from face-center toward the right or left, respective!] The speech sound was, in effect, synchronized with the location of the speech

An octophonic sound capability permits the creation in the media room of veritable "cocktail party" of sounds and voices, any sound so re-created as to giv it a spatially definite apparent source in the room. Endowing sound sources wid specific locales effectively créales a set of "channels," aiding separation and iden

tification of a number of simultaneously heard voices. The possibility of "browsing" through sets of auditory messages, redundandy cued in visual graphics, can make sound as a data type or means of annotation a rich offering to the user.

The ensemble of data types and associated interactions enumerated here form an initial set and by no means exhaust the long-term potentialities of user-system interaction. Before we turn to a consideration of what the future may hold, however, let us set down some of our major findings thus far about using space to organize data.

what we learned

A major lesson of our experience in attempting to use space to articúlate infor-mation was the virtue of straightforward simplicity in the presentational aspects of the user's "virtual" spatial world.

The system as outlined above did not spring into existence all at once but re-sulted from many years of Office of Naval Research research in television-based computer graphics and an initial versión of a spatial data-management system, SDMS I, developed over the project's first year of DARPA support.

SDMS I was a "2-1/2-D" spatial world: a set of 2-D data planes, so linked as to define a hierarchical, "laminar" space. The top level of this structure was Data-iand itself: a large data plañe with "Ítems" of various sorts arranged on its surface, some grouped on common background colors. As described earlier, the large screen in front of the user functioned as a "window" onto Dataland, which ap-peared in its entirety on the small monitor.

Importandy, the scheme of the data space in SDMS I included a system of "ports" on any data plañe or layer, which, when zoomed in on, would give way to a next data layer, seemingly in back of or "beneath" it The information contained on the lower planes was logically subordinate to the topic at the port through which the user dove....

A critical focus of further research involves a set of themes having to do with the active engagement of the user in the environmental space of the interface, ex-panding the spatial domain to encompass the real-space characteristics of user ac-tions. The overall intention is to render the system cognizant of how the user is Dperating in his personal space, as this space intersects with the shared space of the interface: directionalities in looking, speaking, touching, gesturing, together system awareness of user position and proximities.

Among these themes is the awareness of where the user is looking. Eye coi tact is an important adjunct in human interpersonal exchange and, in general, prime indicator of the focus of active awareness.

The opportunity here is for, among other things, an eye-controlled "virtií camera," that is, a display that points, pans, zooms, travels, as a functíon of whei the user is looking. In the context of the imagery in SDMS so far discussed, pa sibilities might include even the trivial example of a spatially dispersed set i iteras, perhaps faces, each of which "talks" when eye-addressed by the user. ti directed gaze used by the system as an implicit "command" or act of selectíoi Another example would be an image, say a map, which locally expands and gaij detail as a function of the point and duration of "looks."

The sense of space in and at the interface includes system awareness of ti user near-field. The tone of appointments in the media room, especially ti openness of the chair, invites the user to get up out of the chair the more irma diately to engage himself with the data. Gesturing, arm waving, pointing, esp cially in conjunction with the line-of-sight indications captured throuj unobtrusive eye tracking, would endow the immediate space between user ai system with communicative meaning.

Space-ranging techniques that permit the system to know where the user in the space of the interface, plus the user's body attitude, have intrinsic uses, system of body-borne space sensors, unobtrusively disposed about a sort of "1 jacket" as buttons, cufflinks, epaulettes, would establish a computer-interpretal dot figure demarking the momentary position and attitude of the user. Amoi other íunctions, such knowledge can help to reestablish tracking contact oían < rant oculometer, making sensing where one is looking a more realistic propo tion in a dynamic environment.

With body sensing in the user near-field, pushing Ítems of virtual data abe in a now-tangible 3-D space arises as a possibility. Or, traffic-patrol-like directi of ítems streaming by in patterns for on-the-fly perusal. The dynamics of (chestration, literally like those of conducting a symphony, arise as realities. i pecially pertinent in an environment of spatially distinct sounds and voices in octaphonic surround. Pointing to virtual talkers with indications to speak, hurry up, to pause, becomes repertorial for the user, now "fleshed out" at Iq minimally in dot form in the augmented space of the interface.

Voice direction with eye contact, a natural combination in the extra syst real world, persist in the realm of user-system interchange as a viable modal The ability to voice-activate takes on more precise meaning and possibilities

conjunction with the ability to address by voice and eye simultaneously in a coordinated fashion. To be able to point by gesture as well defines yet an additional dimensión of voice-and-eye dynamics.

These themes, somewhat synoptically expressed, implícate actions in an explicit space, coextensive with the real room space at the user-system interface, a shared space which can be artfully integrated with the virtual spaces which have been the focus of this, our work, so far.

At stake here is a user-system interface, a data space, so enriched and quickened that the human becomes more than a dimensionless point, the space at the interface something other than empty volumes. The long-term goal is the utmost in usability, where the user's natural modalities and capacities for communicative expression meet with perceptive, complementary system response.

rlarc Lanter

«19» «The New Workstatíon: CD ROM Authoring Systems" (1986)

Marc Canter. © Chip Simons.

"Authoring software should aim to shorten the feedback loop between the computer and the user—between the ¡dea ¡tself and its actualization. The overall outcome is a more dírect comedión

to creativity for the
user."

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"The New Workstation: CD ROM Authoring Systems" 199

« Maro Canter emerged in the 1980s as an amalgamaron of opera singer, rock musician, software programmer, and entrepreneur. With academic credentials from Oberlin College in intermedia art and electronic music, and after a brief stint producing music videos in New York, Canter applied his unusual array of talents to engineering the first commerdal multimedia authoring system. He launched his software company, Macromind, in 1984, when the Apple Macintosh computer made the GUI and its potential for hypermedia applications widely available. Later rechristened Macromedia, its first producís, SoundWorks and VideoWorks, introduced multimedia production to the desktop computer. In 1988, after the first color Macintosh appeared, Canter released the now ubiquitous Director authoring software. What followed was an explosión of newcreative possibilities, along with a good deal of Madison Avenue-style hype. By the cióse of the decade, desktop multimedia grew into a global phenomenon, with Canter at the center of the excitement, transforming the studios of artists, architects, and designers, reinventing the classroom, and altering the business plans of executives from Silicon Valley to Singapore.

Canter's pioneering approach to multimedia authoring tools became the standard for al I forms of new media development. At the core of his approach was a notational system that looks quite similar to a musical score, an intuitive format that could be used easily by the artist. Canter saw the digital artist of the future as a "composer" of al I forms of medía, orchestrating fragments of graphics, an-imation, and text, in juxtaposition with sound and musical passages, into a single artwork. His authoring system made use of "action codes" derived from Alan Kay's Smalltalk language, giving artists without extensive programming ex-perience the ability to incorpórate hyperlinks into their creations by manipulat-ing icons on the computer screen.The metaphors Canter chose to describe this system have become widely adopted, including his meaning for the terms *stage, cast,* and score. This predisposition toward theater and music belies Canter's roots in live performance, and reinforces his visión that desktop multimedia would evolve into the digital *Gesamtkunstwerk.* »

As the reality of CD ROM draws nearer, so does the need for development tools that will help programmers and artists to créate CD applications fast and ef-ficiently.

Currently, most CD ROM applications are text-based, displaying mainly

words and numbers on the screen. But as the technology moves forward, grapl ics and music will be stored on CD ROMs, resulting in a brand-new generada ofapplications.

The tools we use in developing such applications will play an importan! rol in making these projects feasible. As we begin to conceive of complex new us« for CD ROM, the case of use and versatility of our tools will make or break ou concepts from day one.

Among the tools necessaiy for these tasks, authoring systems will probabl be the most importan!. Integral to these systems will be a powerful, easy-to-us notational system that will unify entire multimedia systems on one score,just a an orchestra is unified by the symphonic score used by its conductor. Thes scores will be capable of representing any sort of data, including the "actioi codes" necessary for interactive programming (or authoring).

No longer will it be necessary to "program" a sequence of data or to devis another "search" algorithm. Authoring systems provide the necessary function to nonprogrammers to control the flow of the program, the level of interactiva and the production of the data itself.

For the purposes of this discussion, we will concéntrate on an authoring sys tem for text, art, animation, and music. It will require the simulation of a fairi complex output device (a premastering system) and a very fast (as real-time a possible) development system. This does not mean that this system will not b able to work with text-based CD applications. It just means that the technolog of the future offers us a lot more than just static text, and we must be ready to ere ate and control new media as they become available.

In the following discussion, "user" refers to the user of the authoring systen and "end user" refers to the actual consumer in the home or office using the fina product.

what Is an authoring system?

An authoring system is a set of hardware and software tools for designing Ínter active programs. The hardware makes it possible to convert Information into ¡

machine-readable formal; the software makes it possible for nonprogrammer (which will often be artists and musicians) to créate complex programs by defin ing decisión points, branches, and subroutines.

Authoring systems originated in the mainframe and minicomputer world but many have begun to appear for microcomputers in the past few years. Thi

more sophisticated authoring systems of yesterday and today produce compli-cated logical flowcharts that programmers use to implement their interactive programs. Many of these programs have "intelligent front ends" that ask the users questions to help them develop their programs, like "What sort of question would you like to ask?" or "How many dialog boxes would you like and what will they look like?" Using a development system based on this sort of authoring "language" often takes months, and sometimes years, to produce interactive videodisks or training programs.

The real problem with these types of authoring systems is that they are very hard to use and they do not produce a final product. They produce only an out-line: a structure for a programmer to follow. And they are often entirely text-based, making them ideal for text-based applications but not for graphically oriented or video-based applications.

Any language or program that can control events through time is an authoring system. Computer-controlled lighting systems, slide shows, and video edit-ing are all authoring systems in that (1) they can control sequences and events through time, (2) these sequences can be edited or changed, and (3) these sequences can be saved and retrieved from disc.

Authoring systems have crept into the entertainment world as a form of au-:omation, making the director's Ufe easier by guaranteeing that certain actions will lappen, no matter what. This sort of automation may have cost a number of op-;rators'jobs, but on the whole it has greatly enhanced the quality of special ef-ects in the past few years.

Most of these large expensive systems (including the ones controlling TV stu-lios) are text-based, with the operator/programmer using a CRT to edit se-[uences, in conjunction with dedicated buttons, switches, and levers. But the ncreased interest in graphics and graphic interfaces is spawning a new genera-on of authoring systems that are graphically based.

The MacroMind Sound Vision™ authoring system is graphically based and ses a notational "scoring" system for controlling the flow of the program irough time. It has no language at all but uses the notational system to represent jquential, branching, or even simultaneous events that occur in the program. 'he events may be a combination of text, graphics, music, or animation. This sort f system is a multimedia authoring system, since it can deal with all sorts of ita, not just text.

On SoundVision's score, time moves horizontally from left to right, with ultiple channels of information stacked up vertically. These channels reprent the text, graphics, or music stored in the score.

The scoring system is used by programmers or artists to créate sequences of information that can easily be edited or transformed. This replaces the tradi-tional means of programming: typing text into a document and compiling it. All the data represented on the score of the authoring system can be edited at any time. In other words, there is no source code or compiler to convert the code into executable instructions. Any text or piece of artwork can be edited or changed even after the application is finished.

The notational system is the uniíying element in the authoring system. Text, graphics, animation, and music can all be synchronized and edited on the score. The "action codes," or programming codes, necessary for creating the interac-tive programs can be embedded into the score and edited just like any piece of animation or music. Data generated from any word processor, paint program, or MIDI (musical instrument digital interface) sequencer can be used in the Sound-Vision system.

Simulating the programmed interaction is another necessary part of the authoring process and is achieved via a software/hardware system called a "premastering" system. These premastering units are very expensive, but they make it possible to test the applications before committing them to disc or ROM. Typ-ically, an entire project would have one, maybe two, premastering units to use as simulators.

creating the applications

Education and training applications are certain to become more common on óptica! disc once the production costs can be brought down by using authoring sys-tems and other development tools. Their existence in schools and industry will undoubtedly change the way educators develop curricula, perhaps giving rise to new professions within the educational arena.

3. By being able to customize educational courseware, regional needs can becatered to and accelerated or disabled learners can concéntrate on specialized material.

4. Educators can focus on a particular subject by designing a custom lesson around that subject.
5. Current news can be explained by integrating recent video footage from TV with encyclopedia references to that área of the world or to that world leader.

- Questions relating to the subject matter can be placed on the screen, and each answer associated with a particular screen "button." Behind each button is an action, such as "Jump to an animated sequence for 10 seconds and then return" or "Jump to another document to hear the company theme song and exit" or "Jump to another screen of questions, answer one of them, and branch depending on what answer is given."

These sorts of applications are typical of what an authoring system can créate. It is very important to be able to model or try out some of these interactive ideas before committing them to disc, and an authoring system is designed to do just that: model an application.

Because the people who come up with these interactive ideas are usually not programmers, it is equally important that they are able to model these environments with as little effort and ability as possible. Since teachers, trainers, mar-keting people, technical writers, and managers will probably be the biggest users of authoring systems, the systems must adhere to easy-to-learn user interface standards, such as those found in the Macintosh or MS-Windows environments.

equipment used in an authoring system

The workstation for a CD ROM authoring system would vary according to the actual work being done there. Each workstation will specialize in some íunction and thereby require diíferent types of equipment, though very likely some equipment will be common to every workstation. The basic workstation will include:

3. An IBM AT (or better) with 4M of memory and a 30M hard disk
4. A premastering system to simúlate an output device (or access to it)
5. A mouse or tablet along with a full-feature keyboard

6.

A network of other workstations, and 2400-baud modem Une

A text entry workstation would include optical scanners, voice recognition hardware, and monochrome monitors. Besides a host of text processors, the software available in a workstation like this would intégrate data from various sources: standard word processors, distant databases via phone lines, ASCII, SYLK, dBase, and other standardized data protocols. This would all be necessary to facilitate the task of entering in hundreds of thousands of words per day.

A graphics workstation would include video digitizers, tablets, high-

resolution scanners, and so on. There should also be a photo and video studio with camera and lighting equipment at the disposal of the artists. High-quality color monitors must be standard equipment in a graphics workstation.

Paint programs of every make, color, and size would be standard software in the graphics workstation. Some of the other necessary software "equipment" would include video digitizing and touch-up, graphics processing (like skew, rotate, and distort), optical scanning, and 3D graphics generators. Other paint programs and graphics databases will be compatible with this system.

In this sort of environment, with the right management, artists could crank out a meg of art a day (1,024,000 bytes).

A music or sound effects workstation will require high-quality audio gear (speakers, tape recorders, amplifier, preamplifier) for both recording and playback. Patch bays, MIDI keyboards, processing equipment, sound digitizers, mixers, and microphones should also be standard equipment. Color monitors for displaying composing programs are also necessary.

Special facilities should be prepared with sound dampening, especially in the workstations designated as "audio studios." Each workstation will be equipped with sequencer and composition software with a variety of notational scoring sys-tems available, e.g., Conventional Music Notation and the MusicWorks grid system. Sound effects generation through algorithmic control will probably also be desired, as well as sampled sound editors.

A multimedia scoring system (like SoundVision) will be used to synchronize the music or sound efFects to the animation. Access to other music databases, syn-thesis patches, or algorithms will also be possible with this workstation. A 10-minute composition could be produced in a day at one of these workstations.

An animation workstation requires much the same equipment as the graphics workstation, with some differences. Múltiple monitors can facilitate the si-multaneous viewing, previewing, and editing of data. Videotape recorders, video SEGs (or mixers), and audio equipment are also important to animators who wish to transfer their work onto other media (VHS, Beta, 3/4-inch tape).

The animation workstation of an authoring system is where all the elements of the system are brought together and incorporated into the score. This is where the text and artwork are "animated," the music is synchronized, and the action codes are embedded to control the flow of the interactive programs.

The SoundVision scoring system is the main software element of an animation workstation like this. Other types of development tools could be used to intégrate incompatible data or to configure the premastering system, but creating and editing documents on the score would be the main task of an animator.

So you *can* see there is more thanjust one type of workstation involved in CD ROM project. Managers, designers, and executives could theoretically ?ork in an animation workstation. Arüsts could roam between graphics and annation stations, and producers and directors would have to know them all qually well.

fAILORING YOUR WORKSTATION

lach workstation should be customized to the particular project and application icing produced. One of the best ways to utilize workers' abilities would be to use emote workstations. You could place them anywhere (especially at home) so that *fork* could continué seven days a week and on holidays. And be fun!

ÍOW TO USE AN AUTHORING SYSTEM *\tage One*

The first stage in using an authoring system is to block out the approximate imings and interaction desired in the application. A typical application would iave a menú at the beginning, at least two or three other menus somewhere else, nd some sort of ending section.

Text and artwork (which should have been created earlier), along with acón codes, are placed into a document's score at the approximate locations. Di-log boxes, menus, and buttons, which start off as artwork, soon turn into iteractive controls when an action code is associated with them. The connec-.on between artwork and action code is all done on the score, at the exact •ame desired. (The exact logistics of how to assign an action code in the score i explained below.)

Once a rough draft has been worked out, initial viewings can be used to de-:ct mistakes, wrong codes, or ill-conceived noüons. This process of trying things ut as soon as possible allows the author to correct any grievous errors before ley become uncontrollable.

The material can also be edited at any time, so different sections of the pro-;ct can be polished at diñerent times, and conceivably by difFerent people.

Stage Two

The second stage in using an authoring system (once the timings have beei frozen) is to add more action codes. These codes may link several documents to gether, branch to other sections and return, or even start other applicationg Music and animation can also be added at this stage of the development procesa

Memory limitations and access times are some of the typical problems en countered when developing applications with authoring systems. Once a write releases the tremendous potential of the system, he usually goes overboard anc asks the system to do too much. For instance, jump from a section on DNA syn thesis, to a musical selection by Beethoven, to a survey of Picasso paintings. al in 0:15 second, and then return to the chemistry section and continué the lesson

Authoring systems can help organize and control a huge amount of data, bu it is very easy to overextend yourself. Early on in your design you must determiru how much data is enough. Just how many sequences of animation demonstrat ing the principies of fluid mechanics or wave dynamics will be suflicient to get tru point across? Whatever you decide, it is very important to not be too ambitious Tackle only a small part of a huge task at a time. There will always be room foi more later.

It's important to realize that authoring systems will evolve and grow witj technology. In the future, new types of authoring systems will be designed to taki advantage of new technology. Besides simple menú choices and passive viewing new standards of interacting will develop, such as text entry or real-time input.

•*i*

Stage Three

The final stage of using an authoring system is the debugging of the application Do all the questions make sense? Does the program flow smoothly?

Are there air] interactions that don't go anywhere? Is the artwork less than perfect? Goinj back to the score and changing action codes is as easy as editing text or touch ing up graphics.

This stage is probably the most important one, as it's always that last 5% a an application that can really make or break it.

Because of the nature of authoring systems, applications can evolve an« change as they are worked on. Sections that make perfect sense on paper oftei turn out to be less than expected. Because of this, an authoring system use should always keep an open mind, ever ready to shift gears and do things differ

A good authoring system should facilítate this need by making it as easy as jossible to edit and change the application at any time

Important issues for CD ROM authors

Authoring software should aim to shorten the feedback loop between the com-juter and the user—between the idea itself and its actualization. The overall out-:ome is a more direct connection to creativity for the user and a higher level of >roductivity.

This type of interacüon is exactly what computers were made for: real-time ools. An example of this real-time interaction can be seen in Music Works, where he notes are heard as they are placed onto the score, or in VideoWorks, where ou can edit an image as you watch it animate.

Widespread use of such authoring workstations will enable large groups of rtists and programmers to produce very large databases of text, animation, andlusic. By keeping the notational system as generalized as possible, workstationske this have the potential of controlling Broadway productions or entire televi-lon studios

Tim Berners-Lee

"Information Management: AProposal" (1989)

Tim Berners-Lee. Photo by Fabián Bachrach. Courtesy ofTim Berners-Lee.

Mr? *¡mportant parí.... is the ¡ntegration ofa hypertext system with existing data, so as to provide a universal system, and to achieve crítical usefulness..*

« In the early 1980s, the British engineerTim Berners-Lee began to develop a computer system for the electronic publishing of project management notes at CERN, the partióle physics laboratory ¡n Geneva; Switzerland. This system, named Enquire, was to have enabled the storing, retrieval, and hyperlinking of documents. It was never completed, but Berners-Lee expanded on its underlying :oncepts to explore how a hypertext system might work in conjunction with the Internet.The result ¡s the unassuming proposal reprinted here,which is nothing less than a prospectus for the creation of the World Wide Web.

Berners-Lee's colleagues at CERN largely ignored his proposal, however. Working under his own ¡nitiative, ¡n the fall of 1990 Berners-Lee completed the First Web browser and server software. In 1991, he began to distribute his software, now named the World Wide Web, to scientists over the Internet. After two years of gradual adoption among scientific colleagues, who, like Berners-Lee, used the Next computer, the Web began to take off when Marc Andreesen and a group of gradúate students at the University of Illinois, Campagne-Urbana, adopted the browser for the Macintosh and PC. In 1993, their versión of the browser, Mosaic, was widely distributed on the Internet, transforming the World Wide Web into a mass médium.

Berners-Lee's Web is a software system that unites research, documents, programs, laboratories, and scientists ¡n a fluid, open, hypermedia environment. He proposes a decentralized network to which new servers can be added at any time without the approval of a centralized authority. Berners-Lee's Web is ¡nherently dynamic, capable of expanding at an explosive rate; this was a significant departure from the hierarchical data systems that had previously been the standard. Another cornerstone of the system is the user's ability to annotate documents himself—to write his own "prívate links," as Berners-Lee phrases it here, creating an infinitely expanding variety of connections. While this paper ad-dresses only how the Web might benefit CERN, Berners-Lee was well aware of his system's potential to link documents across the globe, and to transform our ¡nformation culture. It ¡s worth noting that while Berners-Lee focuses here on hypertext, he also addresses the potential to incorpórate sound and image. From the start he saw the Web's eventual embrace of multimedia, which could well prove to be its enduring legacy. »

210 Tim Berners-Lee

***THIS** proposal concerní the management of general information about accelerators and experiments at CERN. It discusses the problems ofloss of information about complex evolving systems and derives a solution based on a distributed hypertext system.*

overview

Many of the discussions of the future at CERN and the LHC era end with the question—"Yes, but how will we ever keep track of such a large project?" Thu proposal provides an answer to such questions. Firstly, it discusses the problem of information access at CERN. Then, it introduces the idea of linked infor mation systems, and compares them with less flexible ways of finding informa-tion.

It then summarises my short experience with non-linear text systems knowi as "hypertext", describes what CERN needs from such a system, and what in-dustry may provide. Finally, it suggests steps we should take to involve ourselva with hypertext now, so that individually and collectively we may understand what we are creating.

losing information at CERN

CERN is a wonderful organisation. It involves several thousand people, many of them very creative, all working toward common goals. Although they are nomi-nally organised into a hierarchical management structure, this does not constrain the way people will communicate, and share information, equipment and software across groups.

The actual observed working structure of the organisation is a multiply connected "web" whose interconnections evolve with time. In this environment, a new person arriving, or someone taking on a new task, is normally given a few [lints as to who would be useful people to talk to. Information about what facil-¡ties exist and how to find out about them travels in the corridor gossip and ocasional newsletters, and the details about what is required to be done spread in i similar way. All things considered, the result is remarkably successful, despite Dccasional misunderstandings and duplicated effort.

A problem, however, is the high turnover of people. When two years is a typcal length of stay, information is constantly being lost. The introduction of the lew people demands a fair amount of their time and that of others before they lave any idea of what goes on. The technical details of past projects are some-imes lost forever, or only recovered after a detective investigation in an emer-¡ency. Often, the information has been recordad, it just cannot be found.

If a CERN experiment were a static once-only development, all the informaion could be written in a big book. As it is, CERN is constantly changing as new deas are produced, as new technology becomes available, and in order to get round unforeseen technical problems. When a change is necessary, it normally ffects only a small part of the organisation. A local reason arises for changing a art of the experiment or detector. At this point, one has to dig around to find out 'hat other parts and people will be affected. Keeping a book up to date becomes npractical, and the structure of the book needs to be constantly revised.

The sort of information we are discussing answers, for example, questions ke

19. Where is this module used?

Who wrote this code? Where does he work?

20. What documents exist about that concept?
21. Which laboratories are included in that project?
22. Which systems depend on this device?
23. What documents refer to this one?

The problems of information loss may be particularly acute at CERN, but in this case (as in certain others), CERN is a model in miniature of the rest of world in a few years' time. CERN now meets some problems which the rest of the world will have to face soon. In 10 years, there may be many commercial solutions to the problems above, while today we need something to allow us to continué.

linked information systems

In providing a system for manipulating this sort of information, the hope would be to allow a pool of information to develop which could grow and evolve witl the organisation and the projects it describes. For this to be possible,

the method of storage must not place its own restraints on the information.

This is why a "web" of notes with links (like references) between them is fa more useful than a fixed hierarchical system. When describing a complex system many people resort to diagrams with circles and arrows. Circles and arrows leaví one free to describe the interrelationships between things in a way that tables, fo example, do not, The system we need is like a diagram of circles and arrowa where circles and arrows can stand for anything.

We can cali the circles nodes, and the arrows links. Suppose each node is lik a small note, summary arricie, or comment. I'm not overly concerned here witl whether it has text or graphics or both. Ideally, it represents or describes one pai ticular person or object. Examples of nodes can be

11. People
12. Software modules
13. Groups of people
14. Projects
15. Concepts
16. Documents
17. Types of hardware
18. Specific hardware objects

The arrows which link circle A to circle B can mean, for example, that A depends on B

24. ispartofB
25. made B
26. refers to B
27. uses B
28. isan example ofB

These circles and arrows, nodes and links, have different significance in var-
3 sorts of conventional diagrams:

GRAM	NODES ARE	ARROWS MEAN
lily tree	People	"Is parent of"
iflow diagram	Software modules	"Passes data to"

icndency	Module	"Depends on"
LT chart	Tasks	"Must be done before"
anisation al chart	People	"Reports to"

The system must allow any sort of information to be entered. Another per- must be able to find the information, sometimes without knowing what he is ing for.

[n practice, it is useful for the system to be aware of the generic types of the s between items ^dependences,£or example), and the types of nodes (people, igs, documents ...) without imposing any limitations.

u Problem with Trees

iny systems are organised hierarchically. The CERNDOC documentation sys- i is an example, as is the Unix file system, and the VMS/HELP system. A tree > the practical advantage of giving every node a unique name. However, it does t allow the system to model the real world. For example, in a hierarchical CLP system such as VMS/HELP, one often gets to a leaf on a tree such as

HELP COMPILER SOURCE_FORMAT PRAGMAS DEFAULTS ly to find a reference to another leaf: "Picase see HELP COMPILER COMMAND OPTIONS DEFAULTS PRAGMAS"

and it is necessary to leave the system and re-enter it. What was needed was a link from one node to another, because in this case *the Information was not naturalh organised into a tree.*

Another example of a tree-structured system is the uucp News system (try "m" under Unix). This is a hierarchical system of discussions ("newsgroups'"), each containing árdeles contributed by many people. It is a very useful method of pooling expertise, but suffers from the inflexibility of a tree. Typically, a dis-cussion under one newsgroup will develop into a different topic, at which point it ought to be in a different part of the tree. (See Figure 1).

The Problem with Keywords

Keywords are a common method of accessing data for which one does not have the exact coordinates. The usual problem with keywords, however, is that tvvo people never choose the same keywords. The keywords then become useful onty to people who already know the application well.

Practical keyword systems (such as that of VAX/NOTES for example) require keywords to be registered. This is already a step in the right direction.

A linked system takes this to the riext logical step. Keywords can be nodea which stand for a concept. A keyword node is then no different from any othei node. One can link documents, etc., to keywords. One can then find keywordj by finding any node to which they are related. In this way, documents on similai topics are indirecdy linked, through their key concepts.

A keyword search then becomes a search starting from a small number o! named nodes, and finding nodes which are ciόse to all of them.

It was for these reasons that I first made a small linked informatioi system, not realising that a term had already been coined for the idea: hyper text.

A solution: hypertext

Personal Experience with Hypertext

In 1980,1 wrote a program for keeping track of software with which I was in volved in the PS control system. Called *Enquire,* it allowed one to store snippet of information, and to link related pieces together in any way. To find information

From mcvax!uunet!pyrdc!pyrn j!rutgers!bellcore!geppetto!duncaa Thu

Mar . , .
Article 93 of alt.hypertext:
Path:
cernvax!mcvax!uunet!pyrdc!pyrnj!rutgers!bellcore!geppetto!duncan

>From: duncan8geppetto.ctt.bellcore.com (Scott Duncan)
Newsgroups: alt.hypertext
Subject: Re: Threat to free information networks
Message-ID: <14646@bellcore.bellcore.com>
Date: 10 Mar 89 21:00:44 GMT
References: <1784.2416BB47Sisishq.FIDONET.ORG> <3437?uhccux.
uhcc . . .
Sender: newsSbellcore.bellcore.cora
Reply-To: duncan@ctt.bellcore.com (Scott Duncan)
Organization: Computer Technology Transfer, Bellcore
Lines: 18

Doug Thompson has written what I felt was a thoughtful article on censorship-my acceptance or rejection of its points is not particularly germane to this posting, however.

In reply Greg Lee has somewhat tersely objected.

My question (and reason for this posting) is to ask where we might logically take this subject for more discussion. Somehow alt.hypertext does not seem to be the proper place.

Would people feel it appropriate to move to alt.individualism or even one of the soc groups. I am not so much concerned with the specific issue of censorship of rec.humor.funny, but the views presented in Greg's article.

Speaking only for myself, of course, I am . . .
Scott P. Duncan (duncanfctt.bellcore.com OR . . .
!bellcore!ctt!duncan)
(Bellcore, 444 Hoes Lañe RRC 1H-210, Piscataway, NJ . .
(201-699-3910 (w) 201-463-3683 (h))

IGURE 1. *An article in the UUCP News scheme. The Subjectfield allows notes on the same topic be linked together within a "newsgroup". The ñame of the* *newsgroup (alt.hypertext) is a '.erarchical ñame. This particular note expresses a problem with the strict tree structure of the heme: this discussion is related to several áreas. Note that the "References," "From"and "Subject" '.lds can all be used to genérate links.*

ie progressed vía the links from one sheet to another, rather like in the oíd imputer game "adventure." I used this for my personal record of people and odules. It was similar to the application *Hypercard* produced more recently by for the Macintosh. A difference was that *Enquire,* although lacking the

ISSi

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Documentation of the RPC project (concept)

Most of the documentation is available on
VMS, with the two principie manuals being
stored in the CERNDOC systera.


29. includes: The VAX/NOTES conference
VXCERN::RPC
30. includes: Test and Example suite
31. includes: RPC BUG LISTS
32. includes: RPC System:
Implementation Cuide
Information for maintenance,
porting, etc.
33. includes: Suggested Development Strategy
for RPC Applications
34. includes: "Notes on RPC", Draft 1, 20 feb
86
35. includes: "Notes on Proposed RPC
Development" 18 Feb 86
36. includes: RPC User Manual
How to build and run a distributed system.
9) includes: Draft Specifications and
Implementation Notes
19. includes: The RPC HELP facility
20. describes: THE REMOTE PROCEDÜRE CALL
PROJECT in DD/OC

Help Display Select Back Quit Mark Goto hiark
Link Add Edit
```

FIGURE 2. *A screen in an Enquire scheme.*

fancy graphics, ran on a multiuser system, and allowed many people to access di same data.

This example is basically a list, so the list of links is more important than di text on the node itself. Note that each link has a type ("includes," for example and may also have comment associated with it. (The bottom line is a menú bar

Soon after my re-arrival at CERN in the DD división, I found that the env ronment was similar to that in PS, and I missed *Enquire.* I therefore produced versión for the VMS, and have used it to keep track of projects, people, groupi experiments, software modules and hardware devices with which I have worket I have found it personally very useful. I have made no effort to make it suitabl for general consumption, but have found that a few people have successful) used it to browse through the projects and find out all sorts of things of their o\» accord.

Hot Spots

Meanwhile, several programs have been made exploring these ideas, both con mercially and academically. Most of them use "hot spots" in documents, ül icons, or highlighted phrases, as sensitive áreas. Touching a hot spot with mouse brings up the relevant information, or expands the text on the screen I include it. Imagine, then, the references in this document, all being associated with the network address of the thing to which they referred, so that while read-ing this document you could skip to them with a click of the mouse.

"Hypertext" is a term coined in the 1960s by Ted Nelson,[1] which has become popular for these systems, although it is used to embrace two different ideas. One idea (which is relevant to this problem) is the concept:

"Hypertext": Human-readable information linked together in an unconstrained way.

The other idea, which is independent and largely a question of technology and time, is of multimedia documents which include graphics, speech and video. I will not discuss this latter aspect further here, although I will use the word "hy-permedia" to indicate that one is not bound to text.

It has been difficult to assess the effect of a large hypermedia system on an or-ganisation, often because these systems never had seriously large-scale use. For this reason, we require large amounts of existing information should be accessi-ble using any new information management system.

CERN requirements

To be a practical system in the CERN environment, there are a number of clear practical requirements.

Remóte access **across networks**	CERN is distributed, and access from remote machines is essential.
Heterogeneity	Access is required to the same data from different types of systems (VM/CMS, Macintosh, VAX/VMS, Unix).
Non-centralisation	Information systems start small and grow. They also start isolated and then merge. A new system must allow existing systems to be linked

together without requiring any central control or coordination.

Access to existing data If we provide access to existing databases as though they were in hypertext form, the system will get offthe ground quicker. This is discussed further below.

Prívate links One must be able to add one's own prívate

Bells and whistles

links to and from public information. One must also be able to annotate links, as well as nodes, privately.
Storage of ASCII text, and display on 24x80 screens, is in the short temí sufficient, and essential. Addition of graphics would be an optional extra with very much less penetration for the moment.

Data Analysis

An intriguing possibility, given a large hypertext datábase with typed links. is that it allows some degree of automaüc analysis. It is possible to search, for ex-ample, for anomalies such as undocumented software or divisions which contain no people. It is possible to genérate lists of people or devices for other purposes, such as mailing lists of people to be informed of changes.

It is also possible to look at the topology oían organisation or a project, and draw conclusions about how it should be managed, and how it could evolve This is particularly useful when the datábase becomes very large, and groups a projects, for example, so interwoven as to make it difficult to see the wood for th< trees.

In a complex place like CERN, it's not always obvious how to divide peopl< into groups. Imagine making a large three-dimensional model, with people rep resented by little spheres, and strings between people who have something ii common at work.

Now imagine picking up the structure and shaking it, until you make soim sense of the tangle: perhaps, you see tightly knit groups in some places, and u some places weak áreas of communication spanned by only a few people. Perhap a linked information system will allow us to see the real structure of the organi sation in which we work.

Live Links

The data to which a link (or a hot spot) refers may be very static, or it may be tem porary. In many cases at CERN information about the state of systems is chang ing all the time. Hypertext allows documents to be linked into "live" data so tha every time the link is followed, the information is retrieved. If one sacrifices portability, it is possible to make following a link fire up a special application, so that diagnostic programs, for example, could be linked directly into the maintenance ^uide.

Nonrequirements

Discussions on hypertext have sometimes tackled the problem of copyright en-forcement and data security. These are of secondary importance at CERN, where information exchange is still more important than secrecy. Authorisation and ac-counting systems for hypertext could conceivably be designed which are very so-phisticated, but they are not proposed here.

In cases where reference must be made to data which is in fact protected, ex-isting file protection systems should be sufficient.

specific applications

The following are three examples of specific places in which the proposed sys-tem would be immediately useful. There are many others.

Development Project Documentation

The Remote procedure Cali project has a skeleton description using *Enquire.* Al-though limited, it is very useful for recording who did what, where they are, what documents exist, etc. Also, one can keep track of users, and can easily append any extra little bits of informadon which come to hand and have nowhere else to be put. Cross-links to other projects, and to databases which contain information on people and documents, would be very useful, and save duplication of information.

Document Retrieval

The CERNDOC system provides the mechanics of storing and prindng documents. A linked system would allow one to browse through concepts, docu-nents, systems and authors, also allowing references between documents to be itored. (Once a document had been found, the exisüng machinery could be in-roked to print it or display it.)

The "Personal Skills Inventory "

Personal skills and experience are just the sort of thing which need hypertext fles ibility. People can be linked to projects they have worked on, which in turn caí be linked to particular machines, programming languages, etc.

the state of the art in hypermedia

An increasing amount of work is being done in hypermedia research at univeí sities and commercial research labs, and some commercial systems have resultec There have been two conferences, Hypertext '87 and '88, and in Washingto D.C., the National Institute of Standards and Technology (NST) hosted a worl shop on standardisation in hypertext, a followup of which will occur durin 1990.

The *Communications ofthe ACM* special issue on hypertext contains man references to hypertext papers.[2] A bibliography on hypertext is given in *Prt ceedings ofthe Hypertext Standardisation Workshop, January 16-18, 1990¡* and a uucp newsgroup alt.hypertext exists.[4] I do not, therefore, give a list here

Browsing Techniques

Much of the academic research is into the human interface side of browsin through a complex information space. Problems addressed are those of makin navigation easy, and avoiding a feeling of being "lost in hyperspace." Whilst dh results ofthe research are interesting, many users at CERN will be accessing th system using primitive termináis, and so advanced window styles are not so in portant for us now.

Interconnection or Publication?

Most systems available today use a single datábase. This is accessed by man users by using a distributed file system. There are few producís which take Te Nelson's idea of a wide "docuverse" literally by allowing links between nodes i different databases. In order to do this, some standardisation would be necessar However, at the standardisation workshop, the emphasis was on standardis; tion ofthe formal for exchangeable media, ñor for networking. This is prompte by the strong push toward publishing of hypermedia information, for example on optical disk. There seems to be a general consensus about the abstract data model which a hypertext system should use.

Many systems have been put together with little or no regard for portability, unfortunately. Some others, although published, are proprietary software which is not for external reléase. However, there are severa! interesting projects and more are appearing all the time. Digital's "Compound Document Archi-tecture" (CDA), for example, is a data model which may be extendible into a hypermedia model, and there are rumours that this is a way Digital would like togo.

Incentives and CALS

The U.S. Department of Defence has given a big incentive to hypermedia re-search by, in effect, specifying hypermedia documentation for future procure-ment. This means that all manuals for parts for defence equipment must be provided in hypermedia form. The acronym CALS stands for Computer-aided Acquisition and Logistic Support.

There is also much support from the publishing industry, and from librarians whose job it is to organise information.

What Will the System Look Like?

Let us see what components a hypertext system at CERN must have.

The only way in which sufficient flexibility can be incorporated is to sepárate the information storage software from the information display software, with a well-defined interface between them. Given the requirement for network access, it is natural to let this clean interface coincide with the physical división between the user and the remote datábase machine.

This división also is important in order to allow the heterogeneity which is required at CERN (and would be a boon for the world in general).

Therefore, **an important phase in the design of the system is to define this interface.** After that, the development of various forms of display program and of datábase server can proceed in parallel. This will have been done well if many different information sources, past, present and future, can be mapped onto the definition, and if many different human interface programs can be written over the years to take advantage of new technology and standards.

accessing existing data

The system must achieve a critical usefulness early on. Existing hypertext systems have had to justify themselves solely on new data. If, however, there was an existing base of data of personnel, for example, to which new data could be linked, the valué of each new piece of data would be greater.

What is required is a gateway program which will map an existing structure onto the hypertext model, and allow limited (perhaps read-only) access to it. This takes the form of a hypertext server written to provide existing information in a form matching the standard interface. One would not imagine the server ac-tually generating a hypertext datábase from an existing one: rather, it would genérate a hypertext view of an existing datábase.

Some examples of systems which could be connected in this way are

uucp News

VAX/Notes

CERNDOC

File systems

The Telephone Book

The uuix manual

This is a Unix electronic conferencing system. A server for uucp news could makes links between notes on the same subject, as well as showing the structure of the conferences. This is Digital's electronic conferencing system. It has a fairly wide following in FermiLab, but much less in CERN. The topology of a conference is quite restricting.[5] This is a document registration and distribution system running on CERN's VM machine. As well as documents, categories and projects, keywords and authors lend themselves to representation as hypertext nodes.[6]

This would allow any file to be linked to from other hypertext documents.
Even this could be viewed as hypertext, with links between people and sections, sections and groups, people and floors of buildings, etc. This is a large body of computer-readable text, currently organised in a fíat way, but which also

contains link information in a standard formal ("See also ...").

Databases A generic tool could perhaps be made to allow any datábase which uses a commercial DBMS to be displayed as a hypertext view.

In some cases, writing these servers would mean unscrambling or obtaining details *ofthe* existing protocols and/or file formáis. It may nol be praclical to pro-vide the full functionality of the original system through hypertext. In general, it will be more important to allow read ; ccess to the general public: it may be that there is a limited number of people who are providing the information, and that they are conteni to use the existing facilities.

It is sometimes possible to en' '-.nce an existing storage system by coding hypertext information in, if one knows that a server will be generating a hypertext representation. In "news" árdeles, for example, one could use (in the text) a standard formal for a reference to another article. This would be picked out by the hypertext gateway and used to genérate a link to that note. This sort of en-hancement will allow greater integration between oíd and new systems.

There will always be a large number of information management systems—we get a lot of added useíulness from being able to cross-link them. However, we will lose out if we try to constrain them, as we will exclude systems and hamper the evolution of hypertext in general.

conclusión

We should work toward a universal linked information system, in which generality and portability are more important than fancy graphics techniques and complex extra facilities.

The aim would be to allow a place to be found for any information or reference which one felt was important, and a way of finding it afterwards. The result should be sufficiently attractive to use that the information contained would grow past a critical threshold, so that the usefulness of the scheme would in turn encourage its increased use.

The passing of this threshold accelerated by allowing large existing databases to be linked together and with new ones.

A Practical Project

Here I suggest the practical steps to go to in order to find a real solution at CERN. After a preliminary discussion of the requirements listed above, a survey of what is available from industry is obviously required. At this stage, we will be looking for systems which are future-proof:

3. Portable, or supported on many platforms.
4. Extendible to new data formats.

We may find that with a little adaptation, parts of the system we need can be combined from various sources: for example, a browser from one source with a datábase from another.

I imagine that two people for 6 to 12 months would be suffícient for this phase of the project.

A second phase would almost certainly involve some programming in order to set up a real system at CERN on many machines. An important part of this, discussed below, is the integration of a hypertext system with existing data, so as to provide a universal system, and to achieve critical usefulness at an early stage.

(. . . and yes, this would provide an excellent project with which to try our new object oriented programming techniques!)

George Landow and Paul Delany

"Hypertext, Hypermedía and Líterary Studíes: The State oFthe Art" (1991)

Marh Amerika, Grammatron. *©Mark Amerika. Courtesy ofMark Amerika.*

"Hypertext... changes oursense of authorshíp, authoríal property, and creativity (or originality) by moving away from the constrictions ofpage-bound technology. In so doing, it promises to nave an effect on cultural and intellectual disciplines as important as those produced by earíler shifts in the technology of cultural memory that followed the invention of writing and printing."

« George Landow has done much to pave the way for the critical acceptance of hypermedla as a médium for creative and academic writing. A noted literary theorist from Brown University—a hotbed for hypertext since Ted Nelson was a fellow there during the 1960s— Landow ¡ntroduced the potential of hypermedia to a generation of writers and scholars eager to explore the medium's possibilities. His associates include noted hyperfiction authors Stuart Moulthrop and Mark Amerika, who began pioneering forms of interactive writing while study-ing hypertext at Brown. Landow also helped develop the Intermedia software sys-tem ¡n the late 1980s, one of the first authoring tools for creating interactive texts. Intermedia was popular among hypermedia enthusiasts at the time and served as a model forTim Berners-Lee's ¡nitial development of the World Wide Web.

Hypertext erodes the rigidity of print by encouraging the reader to navigate its contents freely, clicking through it ¡n múltiple directions, creating a unique, participatory reading experience. Landow, with Paul Delany from Simón Fraser University, discusses hypermedia's impact on reading and writing, and how this ability to reassemble the text is an almost "embarrassingly literal" example of the deconstruction of meaning explored ¡n late-twentieth-century critical theory.

Landow and Delany examine literary conventions, such as footnotes and ¡ndexes, to ¡llústrate how electronic means of linking texts have roots ¡n traditional writing practice. They describe how hypertext extends these devices in such a way that they become central to the reading, transforming the text into a complex network of paragraphs, sentences, and fragments of "textual units" or "lexias," as they are called.The reader's ability to explore this network freely, and disrupt the linearity of the text, enables a dramatic shift from what they regard as hierarchical, centralized, and author-dominated literary forms. Landow and Delany describe this new form as "intertextualities," a terrain where the boundaries between literary works dissolve as they join into a single, vast "docuverse."

While they note that this literature of the future may introduce chaos into the experience of reading, they see a greater potential for an enhanced "technology of cultural memory/' inspired by Vannevar Bush and Douglas Engelbart, that calis for a revitalized cultural dialogue and collaborative exchange between author and reader. »

hypertext, hypermedia and the history of the text

The written text is the stable record of thought, and to achieve this stability the text had to be based on a physical médium: clay, papyrus or paper; tablet, scroll or book.[1] But the text is more thanjust the shadow or trace of a thought already shaped; in a literate culture, the textual structures that have evolved over the cen-turies *determine* thought almost as poweríully as the primal structure that shapes all expression, language. So long as the text was married to a physical media, read-ers and writers took for granted three crucial attributes: that the text was *linear, bounded, undfixed.* Generations of scholars and authors internalized these qual-ities as the rules of thought, and they had pervasive social consequences. We can define *Hypertext* as the use of the computer to transcend the linear, bounded and fixed qualities of the traditional written text.[2] Unlike the static form of the book, a hypertext can be composed, and read, non-sequentially; it is a variable structure, composed of blocks of text (or what Roland Barthes terms *lexia)* and the electronic links that join them.[3] Although conventional reading habits apply within each block, once one starts to follow links from one block to another new rules and new experience apply. Instead of facing a stable object—the book—en-closing an entire text and held between two hands, the hypertext reader sees only the image of a single block of text on the computer screen. Behind that image lies a variable textual structure that can be represented on the screen in different ways, according to the reader's choice of links to follow. Metaphors that can help us to visualise the structure "behind" the screen include a network, a tree diagram, a nest of Chínese boxes, or a web.

The immediate ancestor of modern hypertext was described in a pioneering article by Vannevar Bush in the 1945 *Atlantic Monthly.*[4] Bush called for mechanically linked information-retrieval machines to help scholars and decisión makers in the midst of what was already an explosión of information. In the 1960s Douglas C. Englebart and Theodor H. Nelson began to design and im-plement computer systems that could implement some of these notions of linked texts, and today hypertext as a term refers almost exclusively to computerized hypertext programs, and to the textual structures that can be composed with their aid. Hypertext programs began to be widely available on personal computers in the late 1980s; current examples are *Guide* and *Linkway* for IBM-compatible FCs, *Intermedia* for Macintoshes running A/UX, and *Writing Space* and *HyperCard* for most Macintoshes.

Because hypertext breaks down our habitual way of understanding and ex-periencing texts, it radically challenges students, teachers, and theorists of liter-ature. But it can also provide a revelation, by making visible and explicit mental processes that have always been part of the total experience of reading. For the text as the reader *imagined* it—as opposed to the physical text objectified in the book—never had to be linear, bounded or fixed. A reader couldjump to the last page to see how the story ended; could think of relevant passages in other works: could re-order texts by cutting and pasting. Still, the stubborn materiality of the text constrained such operations: they required some physical task such as flip-ping pages, pulling another book from a shelf, or dismembering the original text beyond repair.[5] Over the centuries, readers developed a repertoire of aids to textual management; these aids operated both within a single volume, and in the re-lations between volumes. They constituted a *proto-hypertext,* in which we can find important models for hypertext design today—though the special powers of the computer allow us to look beyond the textual aids that evolved during the long history of writirig and printing.

Within the individual volume of the traditional book we may find such *internal* hypertextual functions as tables of contents, page-numbers, chapters. verses, rubrications, footnotes, and indexes. Some of these may be assigned by the original author, others by specialists in textual organization such as indexers or printers, or by later generations of scholars. *External* hypertextual functions have traditionally been post-authorial, supplied by librarians and bibliographers. Indeed, once one extends the idea of "a text" to include a collection of volumes the object of study ceases to be bounded, linear or fixed, and some kind of im-plicitly hypertextual organization will always be necessary.

How does hypertext actually work? Two examples, already familiar to most scholars, will help to show its underlying principies. Take first the elementary, but not trivial, question faced by large research libraries: we have a hundred and fifty kilometers or more of shelves—in what order should the books be placed on them? The primitive solution is an accession system, like the British Library. where each new volume is simply added on at the "end" of the shelf, and volumes are classified by *the physical* address of their original placement. Modern systems try to establish a *lógica!* order that places related books together, independent of any particular arrangement of shelves. This créales a kind of hypertextual link-ing, but done on a fixed and one-dimensional basis (so that, for example, one must choose between uniting all the books on the same subject, or all by the same author).

On-line library catalogues, now coming into general use, can be thought of as coarse-grained and rudimentary hypertext systems that support a "virtual" re-arrangement and retrieval of individual volumes at the terminal. However, they are usually limited to a few standardi/ed search categories, such as author, title and subject; and they cannot discriminate between any textual units smaller than a complete book. More sophisticated systems, such as the on-line MLA Bibli-ography, can perform subtler searches, using more detailed descriptors and deal-ing with articles as well as books. But neither deserve to be called truc hypertext systems, because they opérate on textual classifications rather than on the actual underlying complete texts. Truc hypertext must be able to define textual units, and link them in various ways, within an overall textbase or, to use another term now gaining currency, "docuverse."

Our second example of the principies underlying hypertext could be any standard scholarly article in the humanities. In reading an árdele on, say, Joyce's *Ulysses,* one reads through the main text, encounters a symbol that indicates the presence of a footnote, and leaves die main text to read that note, which can con-tain a citadon of passages in *Ulysses* that supposedly support the argument in question as well as information about sources, influences, historical background, or related árdeles. In each case, the reader can follow the link to another text and thus move endrely outside the scholarly article itself. Having completed reading the note—and perhaps some of the texts to which it refers—one returns to the main text and continúes reading until one encounters another note, and again leaves the main text.

This kind of reading constitutes a mental model of hypertext. Suppose now that one could simply touch the page where the symbol of a note, reference, or annotadon appeared, and that act instantly brought into view the material con-tained in a note or even the entire other text—here all of *Ulysses*—to which that note refers. Scholarly articles sitúate themselves within a network of textual re-lations, most of which the print médium keeps out of sight and relatively diffícult to follow—because the referenced (or linked) materials lie spatially distant from the reference mark. Electronic hypertext, in contrast, makes individual refer-ences easy to follow and the endre field of interconnections explicit and easy to navigate. Instant access to the whole network of textual references radically changes both the experience of reading and, ultimately, the nature of that which is read. If our putative Joyce article was linked, through hypertext, to all die other materials it cited, it would exist as part of a much larger system in which die to-tality might count more than die individual document; die article would now ap-pear WOVen more tightly into its context than would a print-technology counterpart. The case with which readers traverse such a system has further consequences: for as they move through this web or network of texts, they con-tinually shift the center—and henee focus or organizing principie—of their in-vestigation and experience. Hypertext provides an infinitely re-centerable system whose provisional point of focus depends upon the choices made by a truly active reader.

Hypertext thus presages a potential revolutíon in literary studies. However. an almost unlimited power to manipúlate texts brings with it conceptual problems of extreme difficulty, which can be summed up by the questions: "What is a unit of text?" and "What are the relevant links between units?" Among tradi-tional textual units the best-recognized and most functional ones are the word, the sentence, and the book. To think of them as commensurable units on a linear scale of magnitude is natural, but misleading. A word is a conceptual unit, a sentence a syntactical one, a book a unit whose identity is largely determined by its traditional status as a physical object. Nonetheless, they are units that can be handled by many kinds of textual aids developed over the whole period of liter-acy. But between the sentence and the book (in terms of magnitude) we find such units as footnotes, paragraphs, chapters and essays; these are less amenable to deíinition, because they are largely informal means of organizing thought.[6] For the same reason, however, they are likely to be important elements for build-ing hypertext structures: they are the kind of mental "chunks" that we use to break a complex issue into components and make it intelligible. In addition, we are beginning to imagine new textual units, not yet codified or even named, that will be specific to the hypertext environment. They will come into being and pass away in the dynamic virtual text of the computer, producís of such broad cogni-tive principies as identity, association and structure.[7]

These deep theoretical implications of hypertext converge with some major points of contemporary literary and semiological theory, particularly with Derrida's emphasis on decentering, with Barthes's conception of the readerly versus the writerly text, with post-modernism's rejection of sequential narratives and unitary perspectives, and with the issue of "intertextuality." In fact, hypertext créales an almost embarrassingly literal embodiment of such concepts....

Finally, hypertext can be expected to have important institutional as well as intellectual effects, for it is at the same time a form of electronic text, a radically new information technology, a mode of publication, and a resource for collabo-rative work. "Both an author's tool and a reader's médium, a hypertext document system allows authors or groups of authors to link information together, créate paths through a Corpus of related material, annotate existing texts, and créate notes that point readers to either bibliographic data or the body of the referenced text.... Readers can browse through linked, cross-referenced, annotated texts in an orderly but nonsequential manner."[8] Such electronic linking shifts the boundaries between individual works as well as those between author and reader and between teacher and student. It also has radical effects upon our experience of author, text, and work, revealing that many of our most cherished, most com-monplace, ideas and altitudes towards literaiy production are the result of the particular technology of information and cultural memoiy that has provided the setting for them. This technology—that of the printing-press, the book, and the library—engenders certain notions of authorial property, authorial uniqueness, and a physically isolated text that hypertext makes untenable. Hypertext his-toricizes many of our most commonplace assumptions, forcing them to descend from the ethereality of abstraction and appear as corollary to a particular technology and historical era. We can be sure that a new era of computerized textu-ality has begun; but what it will be like we are just beginning to imagine.

From Hypertext to Hypermedia

Expository prose, with its linear and propositional structures, has been too much identified with the privileged form of reason itself. Hypertext provides a better model for the mind's ability to re-order the elements of experience by changing the links of association or determination between them. But hypertext, like the traditional text from which it derives, is still a radical reduction—to a schematic visual code—of what was originally a complex physical and intellectual experience, engaging all the five senses. *Hypermedia* takes us even closer to the complex interrelatedness of everyday consciousness; it extends hypertext by re-integrating our visual and auditory faculties into textual experience, linking graphic images, sound and video to verbal signs. Hypermedia seeks to approxi-mate the way our waking minds always make a synthesis of information received from all five senses. Integrating or (re-integrating) touch, taste and smell seems the inevitable consummation of the hypermedia concept.

Consciousness itself is a continuous linking and re-structuring of images se-lected from past, present and future; from the real and the imaginary; from the internal and external realms of experience. Current hypermedia programs have taken only a few, faltering steps towards electronic representation of human memory, fantasy and cognition. Nonetheless, hypermedia is, in conception at least, a much better model of the mind's typical activities than exists in the se-verely restricted code of linear prose. We can argüe, therefore, for a natural pro-gression from the printed word to hypertext and hypermedia—analogous to the progression from painting to still photography, to silent movies, and now to movies with color and sound. This is not to claim that the newer media will altogether supersede the older ones. The black and white photograph remains viable, but is no longer the absolute standard of representation that it was in the nineteenth century. Similarly, the printed book will remain a central element of culture even as the new ways of interacting with texts make their own claims on our attention....

Dispersing the Traditional Text

Although in some not-so-distant future all individual texts may electronically link to one another, thus creating metatextual structures of a kind only partly imaginable at present, less far-reaching forms of hypertextuality have already appeared.[9] We already have works composed in hypertext that join blocks of text by electronic links to each other and to such graphic supplements as illustrations, maps, diagrams, visual directories and overviews. Second, there are the metatexts formed by interlinking individual sections of individual works. A third case is the adaptation for hypertextual presentation of material conceived in book technology. Such adaptations can work with textual units already given by the author. such as the individual sections of *In Memoriam.*[10] Conversely, one may, in the manner of Barthes's treatment of "Sarrasine," impose one's own *lexias* upon a work not explicitly divided into sections.

A fourth kind of hypertext puts a classical linear text, with its order and fix-ity, at the center of the structure. The composer then links various supplemen-tary texts to this center, including critical commentary, textual variants, and chronologically anterior and later texts. In this case, the original text, which retains its oíd form, becomes an unchanging axis from which radíate linked texts that surround it, modifying the reader's experience of this original text-in-a-new-context.[11]

When compared to text as it exists in print technology, all these forms of hypertext evince varying combinations of atomization and dispersal. Unlike the spatial fixity of printed text, no one state of an electronic text is ever final; it can always be changed. Hypertext builds in a second fundamental mode of variation. since electronic links or reading pathways among individual blocks permit different paths through a text. The numerating rhetoric of "first, second, third" so well suited to linear text may appear within individual blocks of text but cannot control the unfolding of understanding in a médium that encourages readers to choose various paths, rather than following a fixed and linear one.

From a literary perspective based on book technology, the effects of electronic linking may appear harmful and dangerous. The notion of an individual, discrete work becomes increasingly undermined and untenable within this form of information technology, as it already has within much contemporary critical theory. Hypertext linking, reader control, and continual re-structuring not only militate against modes of argumentation to which we have become accustomed, but they have other, more general effects. The reader is now faced by a kind of textual randomness. The writer, conversely, loses certain basic controls over his text: the text appears to break down, to fragment and atomize into constituent el-ements (the *lexia* or block of text), and these reading units take on a life of their own as they become more self-contained because they are less dependent on what comes before or after in a linear succession.

At the same time that the individual hypertext block has looser, or less determining bonds to other blocks from the *same work* (to use a terminology that now threatens to become obsolete), it also can bond freely with text created by other authors. In fact, it bonds with whatever text links to it, thereby dissolving notions of the intellectual separation of one text from others as some chemicals destroy the cell membrane of an organism. Destroying the cell membrane will kill the cell; but destroying our conventional notions of textual separation has no fatal consequences. However, it will reconfigure the text and our expectations of it. As an individual block loses its physical and intellectual separation from others when linked electronically to them, it also finds itself dispersed into them. The necessary contextualization and intertextuality produced by situating individual reading units within a network of easily navigable pathways weaves texts, in-cluding those by different authors and those in nonverbal media, tightly together. One efiect is to weaken and even destroy altogether any sense of textual unique-ness, for what is essential in any text appears intermingled with other texts. Such notions are hardly novel to contemporary literary theory, but here again hypertext créales an almost embarrassingly literal reification or actualization of a principie or quality that had seemed particularly abstract and difíicult in its earlier statement. Since much of the appeal, even charra, of these theoretical insights lies in their difíiculty and even preciousness, this more literal presentation promises to disturb theoreticians, in part, of course, because it disturbs status and power relatioris within their—our—íield of expertise. . . .

hypertext and the author

Collaboratíve Work Hypertext demands new modes of reading, writing, teach-ing, and learning. In so doing it créales new understanding of collaborative learn-ing and collaborative work. To most people, "collaboration" suggests two or more scientists, songwriters, or the like working side by side on the same en-deavor, continually conferring as they pursue a project in the same place at the same time. Landow has worked on an essay with a fellow scholar in this manner. One of us, he relates, would type a sentence, at which point the other would ap-prove, qualify, or rewrite it, and then we would proceed to the next sentence. But probably a far more common form of collaboration (and the one used in this in-troduction, whose authors live two thousand miles apart) is "versioning," in which one worker produces a draft that another person dien later edits by mod-ifying and adding. Both of these models require considerable ability to work productively with other people, and evidence suggests that many people lack this quality. According to those who have carried out experiments in collaborative work, a third form proves more common than the first two: the assembly-line or segmentation model of working together, in which individual workers divide up the overall task and work entirely independently. This last mode is the form that most people engaged in collaborative work choose.[12]

Networked hypertext systems like Intermedia offer a fourth model of collaborative work that combines aspects of the three just described. By emphasizing the cooperative interaction of blocks of text, networked hypertext makes all ad-ditions to a system simultaneously a matter of versioning and of the assembly-line mode. Once ensconced within a network of electronic links, a document no longer exists by itself. It always has an active relation to other documents in a way that a book or printed document never can. From this crucial shift in the way texts exist in relation to others derive two principies that determine this fourth form of collaboration: First, any document placed on a networked system that supports electronically linked materials potentially exists in collaboration with any and all other documents on that system; second, any document electronically linked to any other document collaborates with it.

According to the *American Heritage Dictionary,* to *collaborate* can mean either "to work together, especially in a joint intellectual effort" or "to cooperate treasonably, as with an enemy occupying one's countiy." The combination of labor, political power, and aggressiveness that appears in this dictionary defini-

tion well indicates some of the problems that arise when one discusses collabo-rative work. On the one hand, the notion of collaboration embraces notions of working together with others, of forming a community of action. This meaning recognizes that we all exist within social groups, and must make our contributions to them. On the other hand, collaboration also invokes a deep suspicion of work-ing with others, something both aesthetically as well as emotionally engrained since the advent of romanticism, which exalts the idea of individual effort to such i degree that it often fails to recognize or even suppresses the fact that artists and writers work collaboratively with texts created by others.

Most of our intellectual endeavors involve collaboration, but we do not always recognize it. The rules of our culture, particularly those that define intellectual property and authorship, do not encourage such recognition; further, information technology from Gutenberg to the present—the technology of the book—systematically hinders full recognition of collaborative authorship. Hypertext, however, foregrounds this element of collaboration that other technologies of cultural memory suppress. It changes our sense of authorship, authorial property, and creativity (or originality) by moving away from the constrictions of page-bound technology. In so doing, it promises to have an effect on cultural and intellectual disciplines as important as those produced by earlier shifts in the technology of cultural memory that followed the invention of writing and print-ing... ,[13]

part IV

Immersion

ortonHeilig

Fhe Cinema of the Future" (1955)

***Morton Heilig,* Sensorama.**
Courtesy ofScott Fisher,

Thus, individually and collectívely, by thoroughiy applying the methodology ofart, the cinema ofthe Mure will become the fírst art form to reveal the new scientífic woHd to man ¡n the full

sensual vividness and dynamic
vitality ofhis consciousness."

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« Morton Heilig, through a combination of ingenuity, determination, and shee stubbornness, was the first person to attempt to créate what we now cali virtu^ reality. In the 1950s it occurred to him that al I the sensory splendor of life couli be simulated with "reality machines." Heilig was a Hollywood cinematographer and it was as an extensión of cinema that he thought such a machine might bu achieved. With his inclination, albeit amateur, toward the ontological aspirationí of science, Heilig proposed that an artist's expressive powers would be enhancet by a scientific understanding of the senses and perception. H is premise was simple but striking for its time: if an artist controlled the multisensory stimulatior of the audience, he could provide them with the ¡llusión and sensation of firsfc person experience, of actually "being there."

Inspired by short-lived curiosities such as Cinerama and 3-D movies, it occurred to Heilig that a logical extensión of cinema would be to immerse the audience ¡n a fabricated world that engaged all the senses. He believed that by expanding cinema to involve not only sight and sound but also taste, touch, and smell, the traditional fourth wall of film and theater would dissolve, transport-ing the audience into an inhabitable, virtual world; a kind of "experience theater."

Unable to find support in Hollywood for his extraordinary ideas, Heilig moved to México City ¡n 1954, finding himself ¡n a fertile mix of artists, filmmakers, writers, and musicians. There he elaborated on the multidisciplinary concepts found in this remarkable essay, "The Cinema of the Future/'Though not widely read, it served as the basis for two important inventions that Heilig patented in the 1960s.The first was theTelesphere Mask.The second, a quirky, nickelodeon-style arcade machine Heilig aptly dubbed *Sensorama,* catapulted viewers into multisensory excursions through the streets of Brooklyn, and offered other adventures in surrogate travel. While neither device became a popular success, they influenced a generation of engineers fascinated by Heilig's visión of inhabitable movies. »

r andemoniuní reigns supreme in the film industry. Every studio is hastily converting to its own "revolutionary" system—Cinerama, Colorama, Panoramic Screen, Cinemascope, Three-D, and Stereophonic Sound. A dozen marquees in Time Square are luring customers into the realm of a "sensacional new experience."

Everywhere we see the "initiated" holding pencils before the winked eyes of the "uninitiated" explaining the mysteries of 3-D. The crides are lining up pro and con concluding their articles profoundly with "after all, it's the story that counts." Along with other filmgoers desiring orientation, I have been reading these articles and have sadly discovered that they reflect this confusión rather than illuminate it. It is apparent that the inability to cope with the problem stems from a refusal to adopt a wider frame of reference, arid from a meager under-standing of the place art has in life generally.

All living things engage, on a higher or lower level, in a continuous cycle of orientation and action. For example, an animal on a mountain ledge hears a rum-bling sound and sees an avalancha of rocks descending on it. It cries with terror and makes a mighty leap to another ledge. Here in small is the essence of a process that in animáis and man is so automatic—so rapid—as to seem one indivisible act. By careful introspection, however, men have been able to stop its •apid flow, bring it into the light of consciousness, and divide it into three basic aliases. The first, observation (the noise and image of the boulders in our exam-jle), is the reception of isolated impressions or facts. The second, íntegration, is he combining of these isolated facts with the inner needs of the life forcé into an motional unity that prompts and controls action (the animal's sensation of dan-;er and terror). The third, action (the leap to safety), is a change in the creature's ihysical relation to the world.

With the forming of society, different men concentrated on one of these three bases, and by learning to cast the results of their labor into concrete forms (that ould be passed from man to man, and generation to generation) they created sciice, art, and industry. These three have the same methods and aims in the soal body as the mind, heart, and muscle do in individual man. Their goals are ear. For science it is to bestow the máximum knowledge on humanity. For art

is to digest this knowledge into the deeper realms of
feeling, generating emo-
>ns of beauty and love that will guide the crude
energies of mankind to con-
ructive actions. And for industry it is to act on the
material world so as to

ocure more living energy for mankind. The success
with which each field can
proach its goal depends on its understanding of
method. Science has come the
)sest because it has uncovered the individual's
scientific thought processes
d codified it into a clear and systematic method of
experimentation. Con-
ously applying this method, it makes more
discoveries in one year than
iviously were made in millenniums. Writing,
international mail, and interna-
rial conferences have long been efficient ways of
distributing its findings to
manity.

Industry, within the last one hundred years, has also made great strides to-"d
its goal because production geniuses like Ford have rationalized it to the last

degree. They have instigated assembly line, mass production techniques that pour out more food, machines, and íuels in one year than were produced in cen-turies. The problem of distributing its bulky goods has been solved theoretically and only awaits practica! application.

It is the middle field, art, which today is furthest from its goal. The world is woefully barren of peaceful, tolerant, humanitarian feelings and the art that should créate them. And this is because, as yet, art has evolved no clear-cut methodology to make it as efficient as science and industry in creating its prod-uct. Art is now struggling feverishly to achieve this, and only in the light of this struggle and the laws it seeks to establish will we be able to understand the in-novations that prompted this árdele.

The laws of art, like those of science and industry, lie hidden in the subconscious of man. When a primitive man desired to convey to another man the complete emotional texture of an experience that occurred to him he tried to reproduce, as closely as possible, the elements that generated his own emotions. His art was very simple, being limited to the means provided by his own body. He used his voice to growl like the bear that attacked him, pumped his arms and legs to show how he climbed a tree, and then he blew on his listener's face to make him feel the hot breath of the bear. If he were a good storyteller, he would arrange these eñects in more or less the same order they originally happened to him. Of course, his listener would feel everything more intensely if he, and not his friend, were attacked by the bear. But aside from being impossible, this is not advisable, for by listening to his friend's story, he can have all the excitement, learn all the lessons, without paying the price for them.

With time language became more complete. A specific word-sound became associated with the impressions, objects, and feelings in man's experience. Words were useful in conveying the general structure of an event to the mind, but could rarely quicken the listener's pulse the way fresh and direct contact with the original sense elements could—that is unless spoken by a very skilled narrator. And even then not a thousand of his choicest words could convey the sensation of yel-low better than one glance at yellow, or high C better than listening for one sec-ond to high C. And so side by side with verbal language they evolved more direct forms of communication—painting, sculpture, song and dance. They found they could bore deeper into experience by concentrating all their powers of observa-tion on one of nature's aspects and mastering the limited materials necessary to its expression. Materials became more complex and techniques more refined as each art form sought to exploit the full range and delicacy of its own domain. The few ines scratched on a rock developed into the full glory of painting. The singing roice evolved into symphonic music and the few words into the rich fabric of po-;try. For all the apparent variety of the art forms created, there is one thread unit-.ng all of them. And that is man, with his particular organs of perception and jction. For all their ingenuity, a race of blind men could never have evolved painting. Similarly, no matter how much they appreciated movement through their ;yes a race of limbless men could never have developed dancing. Thus art is like i bridge connecting what man can do to what he can perceive.

What we commonly refer to as the "puré arts" are those whose materials are ¡o simple, so pliable, that one artist can master them sufficiently to express his nner feelings to perfection. The painter fashions color, the musician notes, the joet words. Each additional impression of their artistic form is like an electric :harge driving the spectator higher and higher to peaks of puré and intense feel-ng that he rarely experiences in his daily life. The simple materials of the puré rts are apprehensible through only one sense, but this sense is not a necessary ondition ofpurity. Precisión and subtlety of form achieved through *control is* the lecisive factor.

Desiring to convey the full richness of experience in more lifelike form, men ave combined the puré arts into forms known as the "combined" or "secondary rts," such as opera, ballet, and theatre. Their effects were fuller, more spectacuir, but rarely deeper. The essential factor of control was missing. Not only did le artist have to master visual, musical, choreographic, and verbal materials,

ot only did he have to limit the scope of his
imagination to the practical limita-
ons ofa theatre and depend on the

collaborations of dozens of singers,
painters,
ancers, musicians, and actors, but even
after he had masterminded every detail
id rehearsed the cast into perfect form he
had absolutely no way of fixing his
•catión so that it could remain exactly the
same whenever and wherever played.
his was an impasse the artist could never
surmount and never did, until the ar-
ral ofa strange newcomer on the scene—the
machine. The machine with its ge-
us for tireless repetition and infinite
exactitude was an extensión of the limbs
id wül of man. It could be trusted to perform
all his purely mechanical opera-

ms, freeing his energies for more creative tasks.

In the form of the printing press, lithograph, radio, phonograph, and now
levision, the machine has rapidly solved the second part of art's age-old prob-n
—distribution. Painting, poetry, music, drama, and ballet can now reach mil-
>ns of people about the globe as they never could before. But the machine has
ine more. It has entered, as it has done in industry and science, into the very
here of artistic creation itself, providing the artist with a much wider palette of

sense material and enabling him to mold them with precisión into an aesthetic unity as he never could before. And it is the invasión of such a relentlessly efficient and logical apparatus as the machine into the humane and heretofore ro-mantic field of art that not only suggests but necessitates a clear, efficient *methodology* of art.

If at this point we sean back over our very brief history of art forms it becomes apparent that the first law of such an artistic methodology must be: "The nature of man's art is fundamentally rooted in his peculiar psychic apparatus and is lim-ited by the material means at his disposal." Logically, then a proper science of art should be devoted to the revelation of the laws of his psyche and the invention ofbetter means.

Although very little of it was conscious or intentional, nothing demónstrales this research and invention more dramatically than the cinema. The sense was visión—the material, light. The still camera had been invented but it could do no more than a skilled painter could do with time. But when in 1888 the Lumiere Brothers set up a little box before their factory and cranked away at it as a group of workers left, they did something no human being could ever do before. They captured visual movement in a form that could exactly reproduce the moving image as often as desired. Only after countless millenniums of existence had man learned how to do what his visual mechanism can do with no effort at all. With time every part of this new machine, from the lens to the film stock, was im-proved. Lenses were made faster and given wider angles. The iris became ad-justable and the film fmer-grained and faster. Always the criteria of invention were to reproduce as closely as possible man's miraculous mechanism of visión. The addition of color was inevitable. Man sees color, so must his mechanical eye. Now we have the so-called "revolutionary" 3-D and Wide Screen. The excite-ment and confusión are great but they need not be. First, 3-D was invented oveí 50 years ago and shown at the Paris Exposition. Financial, not technical considerations held it up until 1953. The really exciting thing is that thest new devices have clearly and dramatically revealed to everyone what painting, photography, and cinema have been semiconsciously trying to do all along—portray in its full glory the visual world of man as perceived by the human eye.

Side by side with the invention of means to freeze visual movement, machines were developed that could (this also for the first time in human historv freeze sound. But again, the public's deep and natural urge for more complete re alism in its art had to wait on the wheel of finance until 1933. It is the additioi of sound that represents the really great "revolution" in the history of cinema. Foi

with the addition of sound, cinema stepped irrevocably out of the domain of the "puré arts" into the camp of the "combined arts." Rather than attempting to por-tray the whole through the part, it now began attempting to portray the whole di-rectly. But with this tremendous difference from all other composite arts—it could do it without losing *control* or *permanence.* With the help of the machine two radically different sense materials, light and sound, could be dynamically combined into one work without losing any of the control, subtlety, or concrete-ness formerly attained only by the puré arts. Cinema was no longer just a visual art (notwithstanding the effort of some directors to keep it such by shooting visual films and pouring the sound track over it like some pleasant, superíluous goo), but had set itself the task of expressing in all its variety and vitality the full consciousness of man.

Instead of continuing to stumble along this road with the system of hit and miss, let us, according to our first law, deliberately turn to life and study the nature of man's consciousness.

Man's nervous system—sensory nerves, brain, and motor nerves—is the seat of his consciousness. The substance or componen! parts of this consciousness can be determined by the process of elimination. If a man lies still, or, due to some disease or drug, has his motor nerves blocked, his consciousness or wide-awakeness is not diminished in any way. If, however, he closes his eyes, it is. If he stops his ears, it is diminished further. If he pinches his nose and does not taste anything and avoids tactile impressions, his awakeness is diminished consider-ably. And if, as is done in anesthesia, all sensory nerves leading to the brain are blocked, he would lose consciousness completely. (Dreams and internal voices merely being sense impressions of former experiences stored away and served up iater by memory.) Thus we can state our second law: "Consciousness is a composite of all the sense impressions conveyed to the brain by the sensory part of the nervous system which can be divided into the great receiving organs—the eyes, ears, nose, mouth, and skin."

By concentrating on one organ at a time, we can list the various elements af-fecting it. These are, for the eye, peripheral imagery—180° horizontal X 150° vertical, three dimensionality, color and movement; for the ear, pitch, volume, rhythm, sounds, words, and music; for the nose and mouth, odors and flavors; and for the skin, temperature, texture, and pressure. These divisions—although purely subjective and dependent on vocabulary and techniques of reproduc-tion—are nonetheless useful for analysis.

These elements are the building bricks, which when united créate the sensual Porra of man's consciousness, and the science of art must devote itself to invent-

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These elements are the building bricks, which when united créate the sensual brm of man's consciousness, and the science of art must devote itself to inventing techniques for recording and projecting them in their entirety. Celluloid film is a very crude and primitive means of recording light and is already being replaced by a combination televisión camera and magnetic tape recorder. Similarly sound recording on film or plástic records is being replaced by tape recording.

Odors will be reduced to basic qualities the way color is into primary colors, The intensity of these will be recorded on magnetic tape, which in turn will control the reléase from vials into the theatre's air conditioning system. In time all o] the above elements will be recorded, mixed, and prqjected electronically—a red of the cinema of the future being a roll of magnetic tape with a sepárate track foi each sense material. With these problems solved it is easy to imagine the cinema of the future.

Open your eyes, listen, smell, and feel—sense the world in all its magnificení colors, depth, sounds, odors, and textures—this is the cinema of the future!

The screen will not fill only 5% of your visual field as the local movie screei does, or the mere 7.5% of Wide Screen, or 18% of the "miracle mirror" screei of Cinemascope, or the 25% of Cinerama—but 100%. The screen will curve pasi the spectator's ears on both sides and beyond his sphere of visión above anc below. In all the praise about the marvels of "peripheral visión," no one pausec to state that the human eye has a vertical span of 150^{o1} as well as a horizontal on< of 180°. The vertical field is difíicult, but by no means impossible, to provide Planetariums have vertical peripheral visión and the cinema of the future **wil** provide it along similar lines as shown in the accompanying drawing. This 180' X 150° oval will be filled with truc and not illusory depth. Why? Because a¡ demonstrated above this is another essential element of man's consciousness Glasses, however, will not be necessary. Electronic and optical means will be de-vised to créate illusory depth without them.

Cinemascope, despite all the raving of its publicity men that it is the "crown-ing glory" of motion picture development, represents one small step forward, anc one big one backward. Its increase of screen image from 5 to 18% of man's visua field is a definite improvement although there is still 82% to go. It has, howeveí regressed substantially in clarity. One reason that few critics noticed for Citt erama's excellent illusion of reality is its extraordinary clarity. The human eye i¡ one of the most perfect in the animal kingdom. It is not spotty, out-of-focus. oí jumpy the way average movie images are. The image it records is limpid, razor sharp, and solid as a rock, and Cinerama, by using three film strips instead of one and specially designed projectors, makes a great advancement towards this per fection. Cinemascope, on the other hand, by still using only one film strip u cover two and one-half the normal screen área, is also magnifying grain, and soft

ling the focus two and one-half times, making clarity much worse than it is on ie normal screen.[2] The electrically created image of tomorrow's film will be srfect in focus and stability—the grain and spots vanishing along with the film ock.

Stereophonic sound will be developed so that the spectator will be enclosed ithin a sphere, the walls of which will be saturated with dozens of speakers. ounds will come from every direction—the sides, top, back and bottom—as iey do in real life.

The large number of speakers will permit a much better identity of image and)und than is achieved now where the sound leaping from one distant speaker > another is either behind or ahead of the image. The air will be filled with dors and up to the point of discretion or aesthetic function we will feel changes F temperature and the texture of things. We will feel physically and mentally ansported into a new world.

Yes, the cinema of the future will far surpass the "Feelies" of Aldous Huxley's *rave New World.* And like many other things in this book that are nightmarish ecause superficially understood, it will be a great new power, surpassing con-;ntional art forms like a Rocket Ship outspeeds the horse and whose ability to estroy or build men's souls will depend purely on the people behind it.

The mastery of so many sense materials pose another problem—selection. sople already complain about the excess of realism in films and say the new in¡ntions shall plunge us from bad to worse. Although the spirit of their complaint valid, their use of the word "realism" is not. "Realism," or, in aesthetic terms, ¡xperience," is that something which is created by the unity of the outer world ith the inner. No matter how extensive the artist's means, he must use them to •ovoke more of the spectator's participation, not less. For without the active par-:ipation ofthe spectator there can be no transfer of *consciousness, no art.* Thus t is never "too" realistic. When either too much or too little is given, there just n't any "realism." Poor use of cinema's remarkable new powers is no more of a se against them than daubing with oils is a case against painting.

It is estimated that each sense monopolizes man's attention in the following 'oportions:

Sight	70%
Hearing	20%
Smell	5%
Touch	4%
Taste	1%

Men can have their attention led for them as a bird will do by flying across < empty sky, or can willfully direct it as everyone does at the dinner table when si gling one voice out of the maze of chatter. In each case the criterion is "what the point of greatest interest and significance to me?" Thousands of sense ii pressions stimulate the sensory nerves every second of the day, but only one a few are permitted to enter the *realm ofhigher consciousness at a time.* Ti organ that screens them out is the brain. The brain is the storehouse—the mei ory of the physical and spiritual needs of the individual, and through him of t human race, and it is according to this criteria—"what is beneficial for the d velopment of the individual and racial life forcé?" that a decisión is made. We c now state the third law of our methodology of art: "The brain of man shi rapidly from element to element within each sense and from sense to sense in t approximate proportion of sight, 70%; hearing, 20%; smell, 5%; touch, 4%; ai taste, 1%, selecting one impression at a time according to the needs of indivi ual and racial development." These unite into the dynamic stream of sensatio we cali "consciousness." The cinema of the future will be the first direct, ca píete and conscious application of this law. Since the conventional movie seré filis only 5% of the spectator's field of visión, it automatically represents his pa of visual attention and the director needs only to point his camera to control I point of attention. But with the invention ofmeans to ful 100% of the spectato field of visión with sharp imagery, he must solve the problem of visual attenri another way or lose his main aesthetic power.

Every capable artist has been able to draw men into the realm of a nevv t perience by making (either consciously or subconsciously) a profound studj the way their attention shifts. Like a magician he learns to lead man's attend with a line, a color, a gesture, or a sound. Many are the devices to control the sp tator's attention at the opera, ballet, and theatre. But the inability to elimínate I unessential is what loosens their electrifying grip on the attention of a specta and causes them to remain secondary arts.

The evolution of the aesthetic form of cinema can, in a way, be described a continuation of the artist's struggle to master attention. Griffith began using i "close-up" to draw the spectator's attention to a significan! visual detail. Leu with narrow focus fields were devised to throw foreground and background i of focus, riveting the eye only on the sharp part of the image. Pudovkin develoj the close-up in time by varying camera speeds to parallel die varying intensitj man's observations. Eisenstein proclaimed "montage" and Griffith discoveí "parallel cutting," both magnificent weapons in the director's arsenal of attená Shots and scenes could now be shifted with the same freedom and rapidity p

sible in man's natural observation or imagination. Sound arrived with undiminished intensity, but in time it too became refined in contení, pitch, and volume, sometimes dominating the scene, sometimes leaving it completely, leading the ear as precisely as the eye. But like the search for an additional number of sense ma-terials, the principie involved in this refinement of attention were mostly stum-bled on by accident—rarely searched for deliberately, and never formulated consciously.

Again, the only place to search is in the mind of man. We must try to learn how man shifts his attention normally in any situation.

Suppose we are standing on a hilltop overlooking the countryside. First we are struck by the huge sweep of the view before us. Then we notice the vivid green of the fields and the sunshine. Then the silent expansión and rolling of a cumulus cloud entrances us. We feel a warm gust of wind and our nostrils dilate at the smell of new-mown hay. Suddenly, our ears sharpen as the shriek of ajet plañe cuts the air. We cannot see it, but we linger on the way its high-tone low-ers in pitch and fades away. Here is an example of how attention shifts from one element (space—color—then movement, in our example) within a single sense (the eye) and from one sense to another (the eye, the skin, the nose, the ear). In each moment it fixes itself, if for only an instant, on one sense element to the par-tial or complete exclusión of all others.

In life, only the object being observed is in focus. The área of focus is not hec-essarily rectangular, including everything in the same plañe, as it is in today's films, but can be circular, triangular, vertical, or horizontal, depending on the shape of the objects of interest. Electrical and optical means will be developed to duplícate this flexibility, retaining the hazy frame of peripheral visión as the human eye does for added realism. Naturally, the great visual oval of the camera field will include, exclude, move closer, and recede as it does in life. This zone of focus will generally be at the center of the visual field, but it will be free to shift up and down, or around to the sides, leading the eye wherever it goes. The di-rection, quality, and intensity of all other sense elements will be controlled and pin-pointed in the same subtle manner.

Each basic sense will dominate the scene in roughly the same proportion we found them to have in man. That is, sight, 70%; sound, 20%; smell, 5%; touch, 4%; and taste, 1%. Nature turns them on and offwithout a whimper but film-makers once in possession of a new power usually cling to it like a drowning man to a life raft. Eye irritating colors, ear deafening dialogue, and soul sicken-ing music are loaded one on top of another just to "make sure the point gets across." The cinema of the future will turn any and all of it off, including the visual part, when the theme calis for it. For, and it cannot be stressed too strongly, the cinema of the future will no longer be a "visual art," but an "art of con-sciousness."

When a great many sense materials are presented in sharp focus simultane-ously the spectator must do his own selecting. He is no longer being led along by a work of art, but must begin with great fatigue to créate his own patterns. This situation is so life-like that it gives the spectator the sensation of being *physically* in the scene. For example, in Cinerama's famous roller coaster sequence, the spectator's body, not his soul, is riding the roller coaster. This is a tremendous faculty and will, I am sure, be used to great effect in the cinema of the future, but it must be used with great discretion. For aside from being very tiring, after one too many loops, the spectator may be so thoroughly convinced that he is shoot-ing the chutes as to throw up on the lady in front of him. As stated before, art is a specific technique for living vicariously, of weeping without actually losing a loved one, of thrilling to the hunt without being mangled by a lion, in short of reaping the lessons and spiritual nourishment of experience without any loss. The solution of the problem of focus will invalidate the opinión that the wide screen is no good for "the intimate thing." If man can have intímate moments in life with his peripheral visión, stereophonic hearing, smell, and touch, so can his art.

It would seem from the preceding analysis that my conception of the function of the cinema of the future is to faithfully reproduce man's superficial and immediate perception of the world about him. Nothing could be further from the truth. The history of art demónstrales over and over again that some of the most valid experiences come from the inner and not the outer world. But the history. not only of art but any other human endeavor, also proves that the outer precedes the inner. The outer world supplies the raw materials of creation. Man cannot origínate. He can only take the forces of nature and rearrange them into shapes more friendly to his own existence. Just as nature had to provide water, iron, fire. and the laws of thermodynamics before someone could invent the steam engine. so nature must supply man with raw impressions before he can fashion them into an imagery more meaningful and useful to himself. The first task of painting was to copy the world, and only when the camera relieved it of this mirror-like function was it really free to explore the full range of man's fantasy. At first, mo-tion picture cameras and sound recorders could not even capture the simplest as-pects of man's perception of the outer world. Now, though still far from matching some of these, they are far superior to others. Slow motion, fast motion, and in-frared ray photography are able to "see" things no human eye can.

Supersensitive microphones are now able to "hear" sounds way beyond the mge of human ears. Similarly, directors at first had to be contení with what the •atural scene about them oflered. Then, in studios, they began to select and irrange what went before the lens. By building sets, and developing trick pho-;ography, they could set the world of history and fantasy before the lens. Then, by perfecting the technique of animation, they could do without bulky sets and intricate models entirely and give free reign to their wildest imagination.

Sound has followed a similar evolution—from the objective to the subjective world. First we recorded only natural sounds, or the sounds created by human voices and musical instruments. Then we invented a whole series of odd new sound-making instruments and set them about the microphone. Now people like Norman McLaren are dispensing with expensive instruments and microphones entirely and are creating sound never heard before by painting directly on the sound track.

These developments bring us to our fourth law: "In his creative process, man is imposed on by outer impressions. He learns the secrets of their basic principies through imitation and then subjects these to the needs of his own ex-pression. He goes from reception to imitation to creation, i.e., from portraying the outer to portraying the inner world."

This law will inevitably hold true for the cinema of the future. While it still must learn to faithfully reproduce man's outer world as perceived in his consciousness, it will eventually learn to créate totally new sense malcriáis for eachof the senses—shapes, movements, colors, sounds, smells, and tasles—ihey havenever known before, and lo arrange ihem inlo forms of consciousness never before experienced by man in his conlacl wilh ihe outer world

The thealre will provide for ihe full exercise of ihe social instincts. It will incorpórale a promenade and cafe around ihe ihealre proper. The film will nol be presenled as "enterlainmenl" but as an evening of community culture. A speaker will review ihe personalilies in and hislory of ihe film being viewed. Afler ihe performance ihe audience will crilicize ihe film in a discussion facililated by televisión relays and led by a moderator. The audience will be able to continué the discussion in the cafe-lounge or on the promenade where they can see, be seen, and enjoy the evening in a thoroughly social fashion. Thus, individually and col-lectively, by thoroughly applying the methodology of art, the cinema of the future will become the firsl arl form to reveal the new scientific world lo man in ihe full sensual vividness and dynamic vilality of his consciousness.

—translated by uri feldman

Z3

Ivan Butherland

"The Ultímate Gisplay" (1965)

han Sutherland, Head-Mounted Display (worn by Don Vickers). Courtesy ofUniversity ofUtah.

"The ultímate display would, ofcourse, be a room within which the computer can control the existence of matter. A\ chair displayed in such a room would be good enough to si *in. Handcuffs displayed ¡n such a room would be confiningt and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderlandinto which Alice walked."*

« I van Sutherland made his first significant contribution to computer science ¡n 1963 as a twenty-two-year-old gradúate student at MU, where he pioneered the field of Interactive computer graphics with his legendary Sketchpad system. Later, in 1965, while conducting his initial research ¡n ¡mmersive technologies, Sutherland wrote "The Ultímate Display," in which he made the first advance toward marrying the computer to the design, constructlon, navigation, and habitatlon of virtual worlds. This essay has since become known by generations of scientists, computer artists, and media theorists as the seminal statement to define the field of computer-based virtual reality.

Morton Heilig provided the first glimpse of a simulated reality, but had no means to pursue his visión. Sutherland, on the other hand, had access to the abundant resources of ARPA. He predicted that advances in computer science would eventually make it possible to engineer virtual experiences that were convincing to the senses. Sutherland understood that puré information can be expressed in any number of forms, through an ¡nterface of the engineer's choosing. That interface might be the unes of type on a screen, or, he reasoned, ¡t could be a fully realized three-dimensional environment. While this speculation seems influenced more by science fiction than scientific fact, Sutherland believed ¡n the ineffable potential of computers to transform the abstract nature of mathematical constructions into habitable, expressive worlds ¡n the spirit of Lewis Carrol I's *Alice in Wonderland,*

In this essay, Sutherland presents a survey of the hardware and software that would someday constitute the computer-driven "reality" engine. Although it was several years before the invention of the personal computer, Sutherland had already conceived an Interactive, immersive system that went well beyond the keyboard, light pen, and joystick, which were the cutting-edge technologies of the day. In 1966, Sutherland took a crucial step toward the implementation of his visión by inventing the head-mounted display—a helmet-shaped apparatus designed to immerse the viewer ¡n a visually simulated 3-D environment. He completed the prototype ¡n 1970 at the University of Utah, and fondly nicknamed it the "Sword of Damocles," because the mass of hardware threatened to decapítate the immersant.This invention led to the development of the more sophisti-cated and visually arresting representations of reality that became possible with advances in computing power and 3-D graphics. »

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live in a physical world whose properties we have come to know well through long familiarity. We sense an involvement with this physical world which gives us the ability to predict its properties well. For example, we can predict where objects will fall, how well-known shapes look from other angles, and how much forcé is required to push objects against friction. We lack corresponding familiarity with the forces on charged particles, forces in nonuniform fields, the efíects of nonprojective geometric transformations, and high-inertia, low friction motion. A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland.

Computer displays today cover a variety of capabilities. Some have only the fundamental ability to plot dots. Displays being sold now generally have built in line-drawing capability. An ability to draw simple curves would be useful. Some available displays are able to plot very short line segments in arbitrary directions, to form characters or more complex curves. Each of these abilities has a his-tory and a known utility.

It is equally possible for a computer to construct a picture made up of colored áreas. Knowlton's movíe language, BEFLIX,[1] is an excellent example of how computers can produce area-filling pictures. No display available commercially today has the ability to present such area-filling pictures for direct human use. It is likely that new display equipment will have area-filling capability. We have much to learn about how to make good use of this new ability.

The most common direct computer input today is the typewriter keyboard. Typewriters are inexpensive, reliable, and produce easily transmitted signáis.

As more and more on-line systems are used, it is likely that many more typewriter consoles will come into use. Tomorrow's computer [user] will interact with a computer through a typewriter. He ought to know how to touch type.

A variety of other manual-input devices are possible. The light pen or RAND Tablet stylus serve a very useíul function in pointing to displayed Ítems and in drawing or printing for input to the computer. The possibilities for very smooth interaction with the computer through these devices is onlyjust beginning to be exploited. RAND Corporation has in operation today a debugging tool which recognizes printed changes of register contents, and simple pointing and moving motions for format relocation. Using RAND's techniques you can change a digit printed on the screen by merely writing what you want on top of it. If you want to move the contents of one displayed register into another, merely point to the

frrst and "drag" it over to the second. The facility with which such an interaction system lets its user interact with the computer is remarkable.

Knobs and joysticks of various kinds serve a useful function in adjusting parameters of some computation going on. For example, adjustment of the viewing angle of a perspective view is conveniently handled through a three-rotationjoy-stick. Push-buttons with lights are often useful. Syllable voice input should not be ignored.

In many cases the computer program needs to know which part of a picture the man is poinüng at. The two-dimensional nature of pictures makes it impos-sible to order the parts of a picture by neighborhood. Converting from display coordinates to find the object pointed at is, therefore, a time-consuming process. A light pen can interrupt at the time that the display circuits transfer the item being pointed at, thus automatically indicating its address and coordinates. Spe-cial circuits on the RAND Tablet or other position input device can make it serve the same function.

What the program actually needs to know is where in memory is the structure which the man is pointing to. In a display with its own memory, a light pen return tells where in the display file the thing pointed to is, but not necessarily where in main memory. Worse yet, the program really needs to know which sub part of which part the man is pointing to. No existing display equipment computes the depths of recursions that are needed. New displays with analog mem-ories may well loóse the pointing ability altogether.

other types of display

If the task of the display is to serve as a looking-glass into the mathematical won-derland constructed in computer memory, it should serve as many senses as pos-sible. So far as I know, no one seriously proposes computer displays of smell, or taste. Excellent audio displays exist, but unfortunately we have little ability to have the computer produce meaningful sounds. I want to describe for you a kines-thetic display.

The forcé required to move ajoystick could be computer controlledjust as the actuation forcé on the controls of a Link Trainer are changed to give the feel of a real airplane. With such a display, a computer model of particles in an elec-tric field could combine manual control of the position, of a moving charge, replete with the sensation of forces on the charge, with visual presentation of the charge's position. Quite complicated "joysticks" with forcé feedback capability exist. For example, the controls on the General Electric "handyman" are noth-ing but joysticks with nearly as many degrees of freedom as the human arm. By use of such an input/output device, we can add a forcé display to our sight and sound capability.

The computer can easily sense the positions of almost any of our body mus-cles. So far only the muscles of the hands and arms have been used for computer control. There is no reason why these should be the only ones, although our dex-terity with them is so high that they are a natural choice. Our eye dexterity is very high also. Machines to sense and interpret eye motion data can and will be built. It remains to be seen if we can use a language of glances to control a computer. An interesting experiment will be to make the display presentation depend on where we look.

For instance, imagine a triangle so built that whichever córner of it you look at becomes rounded. What would such a triangle look like? Such experiments will lead not only to new methods of controlling machines but also to interesting understandings of the mechanisms of visión.

There is no reason why the objects displayed by a computer have to follow the ordinary rules of physical reality with which we are familiar. The kinesthetic display might be used to simúlate the motions of a negative mass.

The user of one of today's visual displays can easily make solid objects transparent—he can "see through matter!" Concepts which never before had any visual representation can be shown, for example the "constraints" in Sketchpad.[2] By working with such displays of mathematical phenomena we can learn to know them as well as we know our own natural world. Such knowledge is the major promise of computer displays.

The ultímate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confming, and a bullet displayed in such a room would be fatal. With appropriate program-ming such a display could literally be the Wonderland into which Alice walked. ácott Fisher

Virtual InterFace Envíronments" (1989)

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Virtual Interface Environmental Workstation. *Photo by W. Físher and S. Fisher. Courtesy ofScott Fisher, NASA-Ames Research Center.*

'The possibilitíes of virtual realities, ¡t appears, are as Hmitless as the possibilities of reality. They can provide a human interface that disappears—a doorway to other worlds."

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« Scott Fisher is one of the new breed of artist-engineet-s who have emerge in recent years from interdisciplinary academic institutions such as MIT's Ced ter for Advanced Visual Study. While a student ¡n the 1970s, Fisher worked o the groundbreaking Aspen Movie Map project, ¡n which the viewer-participal navigates through an ¡nteractive video-disc representation of Aspen, Colorad! This form of environmental simulation, dubbed "surrogate travel," was a stron influence on Fisher's subsequent work, which ¡ntegrates scientific research ¡n vi tual reality with the artistic application of immersive environments. Inspired t experimenta in simulation such as the nineteenth-century zoetrope, the niel elodeon, Cinerama, Morton Heilig's *Sensorama,* and Ivan Sutherland's heaj mounted display, Fisher's work, which combines these influences, defines oj contemporary notion of virtual reality.

This article documents Fisher's seminal research conducted in the late 1981 at the NASA-Ames Research Center in Mountain View, California, where I worked on the Virtual Environment Workstation (VIEW) project. Intending 1 extend the possibilities of the virtual environment beyond the "surrogate travel of the Aspen project, Fisher set out to develop an interface that would enga< all the senses, thrusting the viewer into a realm of full sensory ¡mmersion.TI NASA system included an updated versión of the head-mounted display, wi stereoscopic images that provided depth of field, a major advancement over ti monoscopic visión of Sutherland's earlier device. Fisher added headphones f surround-sound, a microphone for speech recognition, and, in collaboration w scientistTom Zimmerman, adapted the "dataglove"—the wired glove wom the user that makes ¡t possible to grasp virtual objects in cyberspace.

This multisensory ¡nteraction with cybernetic devices created the powerfu lusion of entering a digitized landscape. By pursuing Heilig's concept of exp< ence theater, Fisher made a significant advance toward what he terrj "telepresence"—the projection of the self into a remote location or virí world.This experience couid range from simulations of undersea exploratiod flights through abstract, imaginary space. Influenced by the work of artist My Krueger, Fisher's research into the use of collaborative telepresent environrr* has led to such diverse applications as telesurgery, architectural walkthrou^ on-line communities,and multi-user games. »

Un the morning ofjuly 29, 2001, Helen and Graham Lesh commuted to work in their accustomed manner. They got up from the breakfast table, kissed each othergoodbyefor the morning, and walked down the hall to their respective workspaces, where they slipped into their datasuits and donned their virtual environment headsets.

An outside observer would see Helen standing almost immobile in the center of her dimly lit space, making a series offine movements with her hands. An outside observer would not be seeing the same environment that Helen saw, however. Helen, a plástic microsurgeon, found herself, as expected, infidl sensory contact with her virtual operating theater: The bright white lights, the blue-garbed OR crew, and the phalanxes ofequipment that surrounded them, looked and sounded exactly as they would in a real operation. Reachingfor a scalpel, murmuring commands to her interface, Helen preparedfor an hour ofintensive rehearsalfor the operation that would take place in the real, life-and-death operating theater at University Hospital thefollowing day.

While Helen was zooming her view in on facial capillaries modeled on those of tomorrow's patient and etching virtual tissue afew hundred molecules at a time with a micromanipulated láser scalpel, Graham was in his workspace, trying to créate a new pharmaceutical. An outside observer would think that Graham was mirmng a wrestling match with himself, or recapitulating his infancy,for Graham was on allfours, his head aimed at a point in space near one córner ofthe workspace. In Graham 's reality, he was crawling around a complex molecule, reaching for other molecules and trying tofit them together, like a kind ofdynamic Tinker-toy.

For the time being, Graham and Helen are fictitious, but they are using perfectly plausible technological descendants ofthe virtual environment display systems that have been developed over the past four years at NASA's Ames Research Center in the Aerospace Human Factors Research División [Fisher et al., 1986, 1987,1988].'

Here, in fací, there is a graphic simulation of a hemoglobin molecule that a person can fly through and move around in physically, as if reduced to molecular size. A head-mounted, wide-angle, stereoscopic display system controlled by operator position, voice, and gesture has been developed for use as a multipur-pose, multimodal interface environment.[1] The system provides a multisensory, Interactive display environment in which a user can virtually explore a 360-degree synthesized or remotely sensed environment and can viscerally interact

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with its components. Our objective has been to develop a new kind of interface that would be very closely matched to human sensory and cognitive capabilities. The eífect of immersing one's sensoria in even the crudest prototypes of these interfaces has led many who have experienced it to refer to the experience as a kind *of virtual reality.* We prefer to use the term *virtual environment* to empha-size the ability to completely immerse a subject in a simulated space with its at-tendant realities.

A bit of history: the evolution of personal simulation and telepresence environments

Matching visual display technology as closely as possible to human cognitive and sensory capabilities in order to better represent "real" experience has been a major ambición for research and industry for decades. One example is the de-velopment of stereoscopic movies in the early 1950s, in which a perception of depth was created by presenting a slighdy different image to each eye of the viewer. In competition with that during the same era was Cinerama, which in-volved three different projectors presenting a wide field of view display to the au-dience. Because the size of the projected image was extended, the viewer's peripheral field of view was also engaged. More recently, along the same lines, the Omnimax projection system sitúales the audience under a huge hemispherical dome, and the film image is predistorted and projected on the dome; the audience is now almost immersed in an image surround.

The idea of sitting inside an image has been used in the field of aerospace sim-ulation for many decades to train pilots and astronauts to safely control complex, expensive vehicles through simulated mission environments. More recendy, this technology has been adapted for entertainment and educational use. "Tour of the Universe" in Toronto and "Star Tours" at Disneyland are among the first entertainment applications of simulation technology and virtual display environments; about 40 people sit in a room on top of a motion platform that moves in synch with a computer-generated and model-based image display of a ride through a simulated universe.

A.spen Movie Map, done *by* the M.I.T. Architecture Machine Group in the late 1970s [Lippman, 1980]. Imageryof the townof Aspen,Colorado, wasshotwith i special camera system mounted on top of a car, filming down every street and around every córner in town, combined with shots above town from cranes, he-licopters, and airplanes and also with shots inside buildings. The Movie Map 2;ave the operators the capability of sitting in front of a touch-sensitive display screen and driving through the town of Aspen at their own rate, taking any route they chose, by touching the screen, indicating what turns they wanted to make and what buildings they wanted to enter. In one configuration, this was set up so that the operator was surrounded by front, back, and side-looking camera im-agery so that, again, they were completely immersed in a virtual environment.

Another notable virtual environment developed for entertainment applications was "Sensorama." This was an elegant prototype of an arcade game de-signed by Morlón Heilig in the mid-1960s and one of the first examples of a multisensory simulation environment that provided more than just visual input. When you put your head up to a binocular viewing optics system, you saw a first-person-viewpoint, stereo-film-loop of a motorcycle ride through New York City and you heard three-dimensional binaural sound that gave you sounds of the city of New York and of the motorcycle moving through it. As you leaned your arms on the handlebar platform built into the prototype and sat in the seat, simulated vibration cues were presented. The prototype also had a fan for wind simulation that combined with a chemical smell bank to blow simulated smells in your face.

Conceptual versions of virtual environments have been described by science fiction writers for many decades. One concept has been called *telepresence,* a technology that would allow remotely situated operators to receive enough sen-sory feedback to feel like they are really at a remote location and are able to do dif-ferent kinds of tasks. Arthur Clarke has described "personalized televisión safaris" in which the operator could virtually explore remote environments with-out danger or discomfort. Heinlein's "waldoes" were similar, but were able to ex-aggerate certain sensory capabilities so that the operator could, for example, control a huge robot. Since 1950, technology has gradually been developed to make telepresence a reality. Research continúes at other laboratories, such as the Naval Ocean Systems Center in Hawaii and MITI's Tele-existence Project in Tsukuba, Japan, to develop improved systems to help humans opérate safely and effectively in hazardous environments such as undersea or outerspace.

One of the first attempts at developing a telepresence visual system was done by the Philco Corporation in 1958. With this system, an operator could see an image from a remote camera on a CRT mounted on his head in front of his eyes

The technology has been moving gradually toward lower-cost personal simulation environments in which viewers are also able to control their own view-point or motion through a virtual environment. An early example of this is the and could control the camera's viewpoint by moving his head [Comeau, 1961]. A variation of the head-mounted display concept was done by Ivan Sutherland in the late 1960s, first at M.I.T.'s Draper Lab in Cambridge, Massachusetts, and then later at the University of Utah [Sutherland, 1968]. This helmet-mounted display had a see-through capability so that computer-generated graphics could be viewed superimposed onto the real environment. As the viewer moved around, the computer-generated objects would appear to be stable within that real environment and could be manipulated with various input devices.

The Virtual Environment Workstation project at NASA Ames (VIEW) is based upon yet another kind of helmet-mounted display technology and, in ad-dition, provides auditory, speech, and gesture interaction within a virtual environment.

the ames virtual environment workstation

The first virtual environment display system developed at Ames was literally a motorcycle helmet with a visor attachment containing two small liquid crystal display screens of 100-by-IOO-pixel resolution. Several iterations of this first pro-totype have resultad in a much lighter, less claustrophobic headset, with a long-term goal of designing a visor-like display package worn on the head. We are currently assembling five versions of this third prototype for use in various re-search environments. Included on the headset is a microphone for connected speech recognition, earphones for 3-D sound cueing, and a head-tracking device, as well as the package to hold the LCD display screens and viewing optics for each eye.

The liquid crystal display screens are inexpensive, fíat panel displays that draw very little power and that have been used specifically for safety reasons and for their lightness. The current resolution is 640 pixels by 220 pixels. These transmissive displays accept a standard NTSC video signal and require some form of backlighting. In the first versión, an LED backlight array was used, and. currently, very bright, miniature fluorescent tubes are being used. Another key part of the display is the very wide-angle optics through which the liquid crystal displays are viewed. The objective is to present a wide-angle field of view that closely matches human binocular visual capabilities rather than just a small win-dow into this 3-D world. These optics allow the displays to completely fill your visual *fíela* of view, thus helping to achieve a sense of presence in the 3-D virtual environment.

On the helmet is a tracking device that tells the host computer where you're looking within the 3-D virtual environment. We're now using an electromag-netic device that measures where the head is within a magnetic field emitted by a source. Azimuth elevation and roll information of the head is combined with XYZ position at a resolution of .03 inch and .10 degree accuracy. When this information is received by the host computer, it's sent to the graphics system or remote camera system so that, as you turn your head, the new position is recorded and a new image that matches that position of regard is displayed. As you turn your head, new images are being drawn so quickly that you feel like you're com-pletely immersed in the virtual environment. Another sensing technology that we're investigating may provide the ability to track eye position in order to dis-play a 3-D cursor within this environment. Eye-tracking will tell us where your eyes are converged in 3-D space so that, for example, you'll be able to trigger menus with your eyes; we'll also be able to present different kinds of depth-of-field information, which is yet another depth cue that has been lacking in typi-cal simulation display systems to date.

Virtual environments in the Ames system are synthesized with 3-D computer-generated imagery, or are remotely sensed by user-controlled, stereoscopic video camera configurations. The computer image system enables high-performance, real-time 3-D graphics presentation at resolutions of 640 by 480 and 1,000 by 1,000 pixels. This imagery is generated at rales up to 30 iraníes per second as re-quired to update image viewpoints in coordination with head and limb motion. Dual independent, synchronized display channels are used to present disparate imagery to each eye of the viewer for truc stereoscopic depth cues. For real-time video input of remote environments, two miniature CCD video cameras are used to provide stereoscopic imagery. Development and evaluation of several head-coupled, remote camera platform and gimbal prototypes is in progress to determine optimal hardware and control configurations for remotely controlled, free-flying, or telerobot-mounted camera systems.

As this display technology evolved to give a feeling of being surrounded by virtual objects or being inside a virtual environment, we also began to develop means of interacting with that virtual world—of literally reaching in and touching the virtual objects, picking them up, interacting with virtual control panels, etc. Earlier research in this área had been done for various applications that re-quired manipulation of remote objects with reasonable dexterity and feedback to the operator. For example, in 1954, Ralph Mosher at General Electric developed the "Handyman" system—a complicated exoskeleton around the operator arm that was used to control a remote robotic arm device. Although operationall useful, this control system was rather large and unportable.

We were interested in getting away from such an invasive device and in 198 contracted VPL Research, Inc., to develop a "dataglove"—a lightweight, flexibl glove instrumentad with flex-sensing devices to measure the amount of bend (eachjoint of the fingers and the amount of abduction, the splay between fingei [Fisher, 1986].[2]

Information from the glove is transmitted to the host computer to represeí what the hand is doing at any moment. In the current, commercially availabl DataGlove, the amount of bend is measured by light attenuation within filx optic bundles covering the fingers, and magnetic tracking devices give absolul position and orientation of the hand within the 3-D space. Position and orienta tion combined with the finger bend is used to control a graphic model of the han in the virtual environment or to control a remote robot hand. With this capabí ity the user can pick up and manipúlate virtual objects that appear in the sui rounding virtual environment [Foley, 1987]. We've also programmed th dataglove so that gestures can be recognized, similar to American sign languag» The operator can make a particular gesture and the host will recognize it as us< input to trigger a particular command or subroutine. For example, pointing \vit one finger moves your viewpoint through the computer-generated environmei as if you were flying through that space, with the distance between your finger an your body determining your velocity; making a fist lets you grab diíferent objectj and using a three-finger point invokes a menú floating in visual space that you ca then use to choose other subroutines or information displays. In actual use. oj erators can design their own set of gestures as preferred.

Additional work in progress for the glove will provide the capability for ta< tile feedback. An array of very small solenoid actuators has been assembled ths will present a sense of texture as you touch a virtual object and, for example. you're touching an edge of a virtual cube, as you intersect the edge of the cubl one Une of the array of solenoids is triggered to present some sense of edgenesi In future scenarios, detailed virtual environment databases or tactile sensors o remote robot end-eñectors will transmit tactile information to arrays such as thi integrated in the DataGlove. A íurther requirement for tactile feedback to the oj erator is forcé reílection, through which some sense of solidity and surfac boundaries of virtual objects is communicated back to the operator. Now, if th hand is closed on a virtual object, the fingers will pass right through the objea

terim solutions include the use of auditory feedback to the operator to indícate ntact with and forces applied to virtual objects. In the longer term, technology required that will constrain the user's fmgers so that they will cióse only to the itside boundary of that virtual object; eventually, full arm and body interaction ill need to be enabled.

The auditory channel is another major part of our sensory input and display search. The auditory display in the VIEW project is capable of presenting a ide variety of binaural sounds to the user vía headphones using sound-synthesis chnology developed for music synthesizers. The primary function of this dis-lay is to provide both discrete and dynamic auditory cues to augment or sup-[y information missing from the visual or gestural displays. For example, discrete jund cues can signal contact between telerobot end-effectors and target ob-cts; alert the operator to attend to information in a data window that is currendy ut of the field of view; or indícate successful recognition of a hand gesture. Sim-arly, auditory parameters can be dynamically modulated and coordinated with ic other subsystem displays to represent, for example, the relative positions of ther objects moving within the virtual environment. In the real world, we also ave a very good sense of where sounds are coming from around us. Additional esearch at Ames has developed an auditory display prototype called the Con-olvotron that is capable of synthetically generating three-dimensional sound ues in real-time. These cues are presented via headphones and are perceived utside of the user's head at a discrete distance and direction in the 3-D space urromiding the user. WVien it is integrated into tlne YIEW system, the postem í the operator can be monitored in real-time and the information used to main-lin up to four localized sound cues in fixed positions or in motion trajectories elative to the user. This capability will further aid the operator's situational wareness by augmenting spatial information from the visual display and pro-iding navigational and cueing aids from outside the field of view [Wenzel et al., 988].

The VIEW system also includes commercially available, speaker-dependent, onnected speech-recognition technology that allows the user to give voice inputi a natural, conversational formal that cannot be achieved with highly con-:rained discrete word recognition systems or through keyboard input. TypicalDeech-mediated interactions are requests for display/report of system status,istructions for supervisory control tasks, and verbal commands to change in-:rface mode or configuration. Taken together, the capabilities of the Virtual En-.ronment Display system described enable a wide range of applications

Telecollaboration

A major near-term goal for the Virtual Environment Workstation Project is to connect at least two of the current prototype interface systems to a common virtual environment datábase. The two users will participate and interact in a shared virtual environment, but each will view it from their relative, spatially disparate viewpoints. The objective is to provide a collaborative workspace in which re-motely located participants can virtually interact with some of the nuances of face-to-face meetings while also having access to their personal dataspace facility. This could enable valuable interaction between scientists collaborating from dif-ferent locations across the country or even between astronauts on a space station and research labs on Earth. With full body tracking capability, it would also be possible for users to be represented in this space by life-size virtual representa-tions of themselves in whatever form they choose—a kind of electronic persona. For interactive theater or interactive fantasy applications, these sryles might range from fantasy figures to inanimate objects, or different figures to different people. Eventually, telecommunication networks may develop that will be configured with virtual environment servers for users to dial into remotely in order to interact with other virtual proxies.

Although the current prototype of the Virtual Environment Workstation has been developed primarily to be used as a laboratory facility, the componente have been designed to be easily replicable for relatively low cost. As the processing power and graphics frame rate on microcomputers quickly increases, portable, personal virtual environment systems will also become available. The possibilities of virtual realities, it appears, are as limitless as the possibilities of re-ality. They can provide a human interface that disappears—a doorway to other worlds.

william bibson

"Academy Leader" (1991)

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William Gibsen. Courtesy of Harén Moskowitz.

> *"A year here and he* sí/'// *dreamed of cyberspace, hope fadíng nightiy. All the speed he took, all the turns he'd taken and the comers he'd cut in Níght City, and* sí/7/ *he'd see the matrix ¡n hís sleep, bríght lattíces oflogíc unfoldíng across that colorless voíd."*
>
> – FROM *NEUROMANCER,* BY WILLIAM GIBSON

« In his science fiction novéis, William Gibson's hallucinatory account of cyberspace provided the first social and spatial blueprint for the digital frontier. In his 1984 novel *Neuromancer-a* colorful, disturbing account of our emerging information society—he added the word *cyberspace* to our vocabulary. His writings explore the implications of a wired, digital culture, and nave had tremendous influence on the scientists, researchers, theorists, and artists working with virtual reality. Gibson's notion of an inhabitable, immersive terrain that exists in the connections between computer networks, a fluid, architectural space that could expand endlessly—an invitation to "jack in"to the "digital matrix"—has opened the door to a new genre of literary and artistic forms, and has shaped our expectations of what is possible ¡n virtual environments.

In this essay, Gibson explains that the word *cyberspace* initially carne to him as a temí without meaning, that ¡t "preceded any concept whatever." He tips his hat to the "dangerous oíd literary gentleman" from East St. Louis, William S. Burroughs, whose acidic depictions of twentieth-century life inspired Gibson's own fictions. He goes on to suggest that in coining the term *cyberspace* he was applying Burroughs's experimental cut-up technique.This entire essay ¡s, ¡n fact, written in the manner of the Burroughs cut-up—with its sudden leaps from one idea to another. It's an appropriate homage to the Beat writer, whose novéis influenced not only Gibson but also an entire generation of dystopian writers, filmmakers, and artists.

In *Neuromancer,* as well as ¡n his later novéis *Count Zero* (1987) and *Mona Lisa Overdrive* (1988), Gibson's visión of cyberspace, with its antiheroes who reside in the void between the physical world and the network, helped spark an age of the posthuman.The cyborgian redefinition of self is staged in such immersive cyber-habitats as M U Ds, virtual communities, and on-line chat spaces, where identity has become malleable and interchangeable. Gibson's strange, menadng virtual world meshed perfectly with the detached, ironic stance of late-twentieth-century culture.

»

music beams back to base."

He phases out on a vector of train whistles and the one particular steel-engraved slant of winter sun these manifestations favor, leaving the faintest tang of Players Navy Cut and opening piano bars of East St. Louis, this dangerous oíd literary gentleman who sent so many of us out, under sealed orders, years ago . . .

Inspector Lee taught a new angle—

Frequencies of silence; blank walls at street level. In the fíat field. We became [ield operators. Decoding the lattices. Patrolling the deep faults. Under the lights. Machine Dreams. The crowds, swept with con ... Shibuya Times Square Pica-dilly. A parked car, an arena of grass, a fountain filled with earth. In the hour of the halogen wolves ... The hour remembered. In radio silence ...

[ust a chance operator in the gasoline crack of history, officer ...

Assembled word *cyberspace* from smalí and readily available components of language. Neologic spasm: the primal act of pop poetics. Preceded any concept whatever. Slick and hollow—awaiting received meaning.

All I did: folded words as taught. Now other words acérete in the interstices.

"Gentlemen, that is not now ñor will it ever be *my* concern ..."

Not what I do.

I work the angle of transit. Vectors of neón plaza, licensed consumers, acts primal and undreamed of...

The architecture of virtual reality imagined as an accretion of dreams: tattoo par-lors, shooting galleries, pinball arcades, dimly lit stalls stacked with damp-stained years of men's magazines, chili joints, premises of unlicensed denturists, of fire-works and cut bait, betting shops, sushi bars, purveyors of sexual appliances, pawnbrokers, wonton counters, love hotels, hotdog stands, tortilla faetones, Chínese greengrocers, liquor stores, herbalists, chiropractors, barbers, bars.

These are dreams of commerce. Above them rise intricate barrios, zones of more prívate fantasy...

Angle of transit sets us down in front of this dusty cardtable in an underground malí in the Darwin Free Trade Zone, muzak-buzz of seroanalysis averages for California-Oregon, factoids on EBV mutation rates and specific translocations at the breakpoint near the c-myc oncogene ...

Kelsey's second week in Australia and her brother is keeping stubbornly in-condo, doing televisión, looping *Gladiator Skull* and a new Japanese game called *Torture Carden.* She walks miles of malí that could as easily be Santa Barbara again or Singapore, buying British fashion magazines, shoplifting Italian eye-shadow; only the stars at night are diñerent, Southern Cross, and the Chinese boys skim the plazas on carbon-fiber skateboards trimmed with neón.

She pauses in front of the unlicensed vendor, his face notched with palé scars of sun-cancer. He has a dozen cassettes laid out for sale, their plástic casi scratched and dusty. "Whole city in there," he says, "Kyoto, yours for a twenty She sees the security man, tall and broad, Kevlar-vested, blue-eyed, homing in I throw the oíd man out, as she tosses the coin on impulse and snatches the thiu up, whatever it is, and turns, smiling blankly, to swan past the guard. She's a] censed consumer, untouchable, and looking back she sees the vendor squintin) grinning his defiance, no sign of the $20 coin ...

No sign of her brother when she returns to the condo. She puts on the glass< and the gloves and slots virtual Kyoto ...

Once perfected, communication technologies rarely die out entirely; rather, tht shrink to fit particular niches in the global info-structure. Crystal radios hai been proposed as a means of conveying optimal seed-planting times to isolate agrarian tribes. The mimeograph, one of many recent dinosaurs of the urba office-place, still shines with undiminished *samisdat* potential in the century backwaters, the Late Victorian answer to desktop publishing. Banks in ui counted Third World villages still crank the day's totals on black Burrougb adding machines, spooling out yards of faint índigo figures on long, oddly festn curls of paper, while the Soviet Union, not yet sold on throw-away new-tech fui has become the last reliable source of vacuum tubes. The eight-track tape formj survives in the truckstops of the Deep South, as a médium for country music an spoken-word pornography.

The Street finds its own uses for things—uses the manufacturers never imaj ined. The micro-tape recorder, originally intended for on-the-jump executh dictation, becomes the revolutionary médium of *magnetisdat,* allowang the cova spread of banned political speeches in Poland and China. The beeper and th cellular phone become economic tools in an increasingly competitive market i illicit drugs. Other technological artifacts unexpectedly become means of con munication ... The aerosol can gives birth to the urban graffitti-matrix. Sovü rockers press homemade ílexidisks out of used chest x-rays ...

Fifteen stones against white sand.

The sandals of a giant who was defeated by a dwarf.

A pavilion of gold, another of silver.

A waterfall where people pray...

Her mother removes the glasses. Her mother looks at the timer. Three houn "But you don't like games, Kelsey..."

“It's not *a* game," tears in her eyes. "It's a city." Her mother puts on the ¡lasses, moves her head from side to side, removes the glasses.

"I want to go there," Kelsey says.

"It's different now. Everything changes."

"I want to go there," Kelsey insists. She puts the glasses back on because the

iook in her mother's eyes frightens her.

The stones, the white sand: cloud-shrouded peaks, islands in the stream ...

She wants to go there ...

"The targeted numeráis of the ACADEMY LEADER were hypnogogic sigils preceding the dreamstate of film."

Marcos Novak

"Liquid Architectures in Cyberspace" (1991)

Marcos Novak, **Liquid** Architectures. © *Marcos Novak. Courtesy of Marcos Novak.*

"Liquid architecture ¡s an architecture that breathes, pulse leaps as one form and lands as another. Liquid architecti is an archítecture whose form is contingent on the interés of the beholder; ¡t ¡s an architecture that opens to welcon me and closes to defend me; ¡t is an architecture wíthout doors and hallways, where the next room ¡s always when need it to be and what I need it to be."

« Marcos Novak describes himself as *a* "trans-architect," due to his work with computer-generated architectural designs, conceived specifically for the virtual domain, that do not exist in the physical world. H is ¡mmersive, three-dimensional creations are responsive to the viewer, transformable though user interaction. Exploring the potential of abstract and mathematically conceived forms, Novak has ¡nvented a set of conceptual tools for thinking about and constructing territories in cyberspace.

In this essay, Novak introduces the concept of "liquid architecture/' a fluid, imaginary landscape that exísts only ¡n the digital domain. Novak suggests a type of architecture cut loóse from the expectations of logic, perspective, and the laws of gravity, one that does not conform to the rational constraints of Euclidean geometries. He views trans-architecture as an expression of the "fourth dimensión," which incorporates time alongside space among its primary elements. Novak's liquid architecture bends, rotates, and mutates ¡n ¡nteraction with the person who inhabits it. In liquid architecture, "science and art, the worldly and the spiritual, the contingent and the permanent," converge in a poetics of space made possible by emerging, virtual reality technologies.

Novak describes his work as a process of metamorphosis, a "symphony of space," in which *3-D* constructions have the properties of music, an experience ie has since referred to as "navigable music." His is a poetic language that attempts to describe the indescribable—"cyberspace as habitat of the imagination, a habitat for the imagination." »

[ntroduction

kVhat is cyberspace? Here is one composite deímition:

> Cyberspace is a completely spatialized visualizaron of all information in global information processing systems, along pathways provided by present and future Communications networks, enabling full copresence and interaction of múltiple users, allowing input and output from and to the full human sensorium, permit-ting simulations of real and virtual realities, remote data collection and control through telepresence, and total integration and intercommunication with a full range of intelligent producís and environments in real space.[1]

Cyberspace involves a reversal of the current mode of interaction with comuterized information. At present such information is external to us. The idea of

cyberspace subverts that relation; we are now within information. In order to do so we ourselves must be reduced to bits, represented in the system, and in the process become information anew.

Cyberspace ofíers the opportunity of maximizing the benefits of separating *data, information, andform,* a separation made possible by digital technology. By reducing selves, objects, and processes to the same underlying ground-zero representation as binary streams, cyberspace permits us to uncover previously invisible relations simply by modiíying the normal mapping from data to representation.

To the composite deíinition above I add the following: Cyberspace is a habitat for the imagination. Our interaction with computers so far has primarily been one of clear, linear thinking. Poetic thinking is of an entirely different order. To lócate the diíference in terms related to computers: poetic thinking is to linear thinking as random access memory is to sequential access memory. Everything that can be stored one way can be stored the other; but in the case of sequential storage the time required for retrieval makes all but the most predictable strate-gies for extracting information prohibitively expensive.

Cyberspace is a habitat of the imagination, a habitat for the imagination. Cyberspace is the place where conscious dreaming meets subconscious dreaming, a landscape of rational magic, of mystical reason, the locus and triumph of poetr)) over poverty, of "it-can-be-so" over "it-should-be-so."

> The greater task will not be to impose science on poetry, but to restore poetry to science.

This chapter is an investigation of the issues that arise when we consider cyberspace as an inevitable development in the interaction of humans with computers. To the extent that this development inverts the present relationship oi human to information, placing the human within the information space, it is an architectural problem; but, beyond this, cyberspace has an architecture of iü own and, furthermore, can contain architecture. To repeat: cyberspace *is* architecture; cyberspace *has* an architecture; and cyberspace *contains* architecture.

Cyberspace relies on a mix of technologies, some available, some still imag-inary. This chapter will not dwell on technology. Still, one brief comment is ap propriate here. A great number of devices are being developed and tested thai promise to allow us to enter cyberspace with our bodies. As intriguing as this maj sound, it flies in the face of the most ancient dream of all: magic, or the desire te will the world into action. Cyberspace will no doubt have physical aspects; thi visceral has genuine power over us. And though one of the major themes of thii essay has to do with the increasing recognition of the physicality of the mind, I find it unlikely that once inside we will tolérate such heavy devices for long. Gloves and helmets and suits and vehicles are all mechanocybernetic inventions that still rely on the major motor systems of the body, and therefore on coarse motor coordination, and more importantly, low nerve-ending density. The course of invention has been to follow the course of desire, with its access to the parts of our bodies that have the most nerve endings. When we enter cyberspace we will expect to feel the mass of our bodies, the reluctance of our skeleton; but we will choose to *control* with our eyes, fingertips, lips, and tongues, even genitals.

The trajectory of Western thought has been one moving from the concrete to the abstract, from the body to the mind; recent thought, however, has been press-ing upon us the frailty of that Cartesian distinction. The mind is a property of the body, and lives and dies with it. Everywhere we turn we see signs of this recognition, and cyberspace, in its literal placement of the body in spaces invented en-tirely by the mind, is located directly upon this blurring boundary, this fault.

At the same time as we are becoming convinced of the embodiment of the mind, we are witnessing the acknowledgment of the inseparability of the two in another way: the mind affects what we perceive as real. Objective reality itself seems to be a construct of our mind, and thus becomes subjective.

The "reality" that remains seems to be the reality of fiction. This is the reality of what can be expressed, of how meaning emerges. The trajectory of thought seems to be from concrete to abstract to concrete again, but the new concreteness is not that of Truth, but *of embodied* fiction.

The difference between embodied fiction and Truth is that we are the authors of fiction. Fiction is there to serve our purposes, serious or playful, and to the ex-tent that our purposes change as we change, its embodiment also changes. Thus, while we reassert the body, we grant it the freedom to change at whim, to become liquid.

It is in this spirit that the term *liquid architecture* is offered. Liquid architecture of cyberspace; liquid architecture in cyberspace.

part one: cyberspace

Poetics and Cyberspace

> Well then, before reading poems aloud to so many people, the first thing one must do is invoke the *duende.* This is the only way all of you will succeed at the hard task of understanding metaphors as soon as they arise, without depending on in-telligence or the critical apparatus, and be able to capture, as fast as it is read, the rhythmic design of the poem. For the quality of a poem can never be judged on just one reading, especially not poems like these which are fall of what I call "poetic facts" that respond to a purely poetic logic and follow the constructs of emotion and of poetic architecture. Poems like these are not likely to be under-stood without the cordial help of the *duende.*
>
> —Federico García Lorca, *Poet in New York*

The *duende* is a spirit, a demon, invoked to make comprehensible a "poetic fact." an "hecho poético." An "hecho poético," in turn, is a poetic image that is not based on analogy and bears no direct, logical explanation (Lorca, 1989). Thu freeing of language from one-to-one correspondence, and the parallel invoca-tion of a "demon" that permits access to meanings that are beyond ordinary language, permits Lorca to produce some of the most powerful and surprising poetry ever written. It is this power that we need to harness in order to be abh to contend with what William Gibson called the "unimaginable complexity" o cyberspace.

How does this poetry opérate?

Concepts, like subatomic particles, can be thought to have world lines **ii** space-time. We can draw Feynman diagrams for everything that we can ñame tracing the trajectories from our first encounter with an idea to its latest incarna tion. In the realm of prose, the world lines of similar concepts are not permitte< to overlap, as that would imply that during that time we would be unable to dis tinguish one concept from another. In poetry, however, as in the realm of quan tum mechanics, world lines may overlap, split, divide, blink out of existence. an< spontaneously reemerge.[2] Meanings overlap, but in doing so cali forth associa tions inaccessible to prose. Metaphor moves mountains. Visualization recon cues contradiction by a surreal and permissive blending of the disparate and fa removed. Everything can modify everything: *"Green oh how I love you green,* writes Lorca, *"Giantstars offrost/come with the shadow-fish/ that leads the wa for dawn. / Thefig tree chafes its wind/with its sandpapered branches, /and th mountain, untamed cat, / bristles sour maguey spears?*

If cyberspace holds an immense fascination, it is not simply the fascination o the new. Cyberspace stands to thought as flight stands to crawling. The root o this fascination is the promise of control over the world by the power of the wil In other words, it is the ancient dream of magic that finally nears awakening inti some kind of reality. But since it is technology that promises to deliver this dreara

the question of "how" must be confronted. Simply stated, the question is, What is the technology of magic? For the answer we must turn not only to computer science but to the most ancient of arts, perhaps the only art: poetry. It is in poetry that we find a developed understanding of the workings of magic, and not only that, but a wise and powerful knowledge of its purposes and potentials. Cy-berspace is poetry inhabited, and to navigate through it is to become a leaf on the wind of a dream.

Tools of poets: image and rhythm, meter and accent, alliteration and rhyme, tautology, simile, analogy, metaphor, strophe and antistrophe, antithesis, balance and caesura, enjambment and closure, assonance and consonance, elisión and in-flection, hyperbole, lift, onomatopoeia, prosody, trope, tensión, ellipsis... poetic devices that allow an inflection of language to produce an inflection of meaning. By push and pulí applied to both syntax and symbol, we navigate through a space of meaning that is sensitive to the most minute variations in articulation. Poetry is liquid language.

As difficult as it may sound, it is with operations such as these that we need to contend in cyberspace. Nothing less can sufFice.

> I ara in cyberspace. I once again resort to a freer writing, a writing more fluid and random. I need to purge a mountain of brown thoughts whose decay blocks my way. I seek the color of being in a place where information ílies and glitters, con-nections hiss and rattle, my thought is my arrow. I combine words and occupy places that are the consequence of those words. Every médium has its own words, every mixture of words has a potential for meaning. Poets have always known this. Now I can mix the words of difíerent media and watch the meaning become navigable, enter it, watch magic and music merge....

Underlying Considerations

Vi inimal Restriction and Maximal Binding The key metaphor for cyberspace is "being there," where both the "being" and the "there" are user-controlled variables, and the primary principie is that *ofminimal restriction,* that is, that it is not only desirable but necessary to impose as few restrictions as possible on the definition of cyberspace, this in order to allow both case of implementation and richness of experience. In addition, *maximal bindingimplies* that in cyberspace anything can be combined with anything and made to "adhere," and that it is the responsibility of the user to discern what the implications of the combination are for any given circumstance. Of course, defaults are given to get things started, but the full wealth of opportunity will only be harvested by those willing and able I customize their universe. Cyberspace is thus a user-driven, self-organizing syi tem.

Múltiple Representations Cyberspace is an invented world; as a world it n quires "physics," "subjects" and "objects," "processes," a full ecology. But sítm it is an invented world, an embodied fiction, one built on a fundamental repn sentation of our own devising, it permits us to redirect data streams into diñe ent representations: selves become múltiple, physics become variable, cognirio becomes extensible. The boundaries between subject and object are conva tional and utilitarian; at any given time the data representing a user may be con bined with the data representing an object to produce ... what?

Digital technology has brought a dissociation between data, informatioi form, and appearance. Form is now governed by representation, data is a binai stream, and information is pattern perceived in the data after the data has be« seen through the expectations of a representation scheme or code. A stream i bits, initially formless, is given form by a representation scheme, and informado emerges through the interaction of the data with the representation; difiera representations allow different correlations to become apparent within the san body of data. Appearance is a late aftereffect, simply a consequence of mal sunken layers of patterns acting upon patterns, some patterns acting as dat some as codes. This leads to an interesting question: what is the informaric conveyed by the representation that goes beyond that which is in the data itsell If a body of data seen one way conveys different information than the same bot of data seen another way, what is the additional information provided by one fon that is not provided by the other? Clearly, the answer is *pattern,* that *is,perceivi* structure. And if different representations provide different perceived inform don, how do we choose representations? Not only do different representado! provide different information, but in the comparison *between* representatioi new information may become apparent. We can thus distinguish two kinds i *emergent* information: *intrarepresentational* and *interrepresentational.*

I substitute the characters on this and the next page of this text with grey scale valúes; two images emerge, pleasingly rhythmical. The gray tone of the letter e i stands out, forming snakes along the pages; I apply spline curves to the snakes. and, in another space, my text itself is changing—what will it say? Now I combine the two pages, and convert the result into a landscape, using the grey valúes to represent height. What snakes were left after the combination of the two pages

become Serpent Mounds. The Others who were reading my text with me a while ago are now flying over this landscape with me, but only I can command it to change. Today....

'rom Poetics to Architecture We have examined various aspects of cyberspace rom a viewpoint that stresses the power of poetic language over ordinary, re-luctive language. Poetic language is language in the process of making and is best tudied by ciòse examination of poetic artifacts, or, better yet, by making poetic rtifacts.

The transition from real space to cyberspace, from prose to poetry, from fact) fiction, from static to dynamic, from passive to active, from the fixed in all its >rms to the fluid in its everchanging countenance, is best understood by exam-úng that human effort that combines science and art, the worldly and the spir-ual, the contingent and the permanent: architecture.

Even as cyberspace represents the acceptance of the body in the realm of the iind, it attempts to escape the mortal plañe by allowing everything to be con-:rted to a common currency of exchange. Architecture, especially visionary ar-ihecture, the architecture of the excess of possibility, represents the anifestation of the mind in the realm of the body, but it also attempts to escape e confines of a limiting reality. The story of both these efforts is illuminating, id in both directions. Cyberspace, as a world of our creation, makes us con-mplate the possibility that the reality we exist in is already a sort of "cyber-•ace," and the difficulties we would have in understanding what is real if such jre the case. Architecture, in its strategies for dealing with a constraining real-', suggests ways in which the limitations of a fictional reality may be sur-aunted.

Architecture, most fundameritally, is the art of space. There are three funda-;ntal requirements for the perception of space: reference, delimitation, and)dulation. If any one is absent, space is indistinguishable from nonspace, being m nothingness. This, of course, is the fundamental observation of categorical ativity. This suggests that cyberspace does not exist until a distance can be per-ved between subject and boundary, that is to say, until it is delimited and mod-ted.

A space modulated so as to allow a subject to observe it but not to inhabit it isually called sculpture. A space modulated in a way that allows a subject to er and inhabit it is called architecture. Clearly, these categories overlap a great il: architecture is sculptural, and sculpture can be inhabited. We can now draw an association between sculpture and the manner in which we are accustomed to interacting with computers. The interface is a modulate information space that remains external to us, though we may créate elabora spatial visualizations of its inner structure in our minds. Cyberspace, on the otb hand, is intrinsically about a space that we enter. To the extent that this space wholly artificial, even if it occasionally looks "natural," it is a modulated spac an architectural space. But more than asserting that there is architecture withi Cyberspace, it is more appropriate to say that cyberspace cannot exist without a chitecture, cyberspace is architecture, albeit of a new kind, itself long dreamed (

> .,. and we can in our Thought and Imagination contrive perfect Forms of Build-ings entirely sepárate from Matter, by settling and regulating in a certain Order. the Disposition and Conjunction of the Lines and Angles.
>
> —León Battista Alberti, *The Ten Books of Architecture*

Visionary Architecture: The Excess of Possibility

Just as poetry differs from prose in its controlled intoxication with meanings be found beyond the limits of ordinary language, so visionary architecture < ceeds ordinary architecture in its search for the conceivable. Visionary archín ture, like poetry, seeks an extreme, any extreme: beauty, awe, structure, or the b of structure, enormous weight, lightness, expense, economy, detail, complex universality, uniqueness. In this search for that which is beyond the immedia it proposes embodiments of ideas Üiat are both powerful and concise. More of than not these proposals are well beyond what can be built. This is not a we ness: in this precisely is to be found the poignancy of visión.

The Space of Art In imagining how information is to be "spatialized" in berspace, it is easy to be overwhelmed by the idea of "entering" the computa the first place, and to only consider relatively mundane depictions of space: p spectival space, graph space, the space of various simple projection systems. I manity's library of depictions of space is far richer than that: synchronically i diachronically, across the globe and through time, artists have inventad a wa of spatial systems. What would it be like to be inside a cubist universe? a hi«

glyphic universe? a universe of cave drawings or Magritte paintings? Just as al-ternative renditions of the same reality by different artists, each with a particular style, can bring to our attention otherwise invisible aspects of that reality, so too can different modes of cyberspace provide new ways of interrogating the world.

The development of abstract art by Malevich, Kandinsky, Klee, Mondrian, and other early modern artists prefigures cyberspace in that it is an explicit turn-ing away from representing known nature. Perhaps artists have always inventad worlds—one is reminded how varied the representations used in the arts have been—from Chínese watercolors, to Byzantine icons, to the strange, conflicting backgrounds of Leonardo—but those worlds usually made reference to some familiar reality. Even when that reality was of a cosmic or mystical nature, we find an assumption of similarity to the everyday world. Modern artists took on the task of inventing entire worlds without explicit reference to external reality. Malevich is pertinent: his *architectones* are architectural studies imagined to exist in a world beyond gravity, *against gravity.* Created as an architecture without íunc-tional program or physical constraint, they are also studies for an *absolute architecture,* in the same sense that we speak of absolute music, architecture for the sake of architecture. Paul Klee, in his dairies, speaks about being a "god" in a universe of his own making.

The paintings of Max Ernst or, even more so, Hieronymous Bosch come to mind, for their ability to créate mysterious new worlds. In the works of these artists we not only see worlds fashioned out of unlikely combinations of a code consisting of familiar elements, but also meaningful crossings of expected conceptual and categorical boundaries.

As with cyberspace, the space of art *is* architecture, *has* an architecture and*contains* architecture. It *is* architecture in its ability to créate a finely controlledsense of depth, even within depictions that are inherently two-dimensional; it *has*an architecture in its compositional structure; and, by depiction, it *contains* architecture. It can serve as a bridge between cyberspace and architecture

Cyberspace Architecture

Architecture has been earthbound, even though its aspirations have not. Buck-minster Fuller remarked that he was surprised that, in spite of all the advances made in the technology of building, architecture remained rooted to the ground by the most mundane of its functions, plumbing. Rooted by waste matter, architecture has nevertheless attempted to fly in dreams and projects, Mies and cathe-irals.

Architecture has never suffered a lack of fertile dreams. Once, however. in times far less advanced technologically, the distance between visión and embod-iment was smaller, even though the effort required for that embodiment wai often crushing. Most "grand traditions" began with an experimental stage oi danger and discovery and did not become fossilized until much laten Hard as i) may be for us to fathom, a gothic cathedral was an extended experiment often last ing over a century, at the end of which there was the literal risk of collapse. Tin dream and the making were one. Curiously, the practice of architecture has *be*-come increasingly disengaged from those dreams. Cyberspace permits the schisrc that has emerged to be bridged once again.

Cyberspace alters the ways in which architecture is conceived and perceived Beyond computer-aided design (CAD), design computing (DC), or the devel opment of new formal means of describing, generating, and transforming archi tectural form, Cyberspace encodes architectural knowledge in a way that indícate; that our conception of architecture is becoming increasingly musical, that archi tecture is spatialized music. Computational composition, in turn, combines thea new methods with higher-level compositional concepts of overall form subject a local and global constraints to transform an input pattern into a finished work In principie, and with the proper architectural knowledge, any pattern can Ix made into a work of architecture, just as any pattern can be made into music. U order for the data pattern to qualify as music or architecture it is passed througl compositional "filters," processes that select and massage the data according U the intentions of the architect and the perceptual capacity of the viewer. Thi "adaptive fütering," to use a neural net term, provides the beginning of the intelligence that constitutes a Cyberspace and not a hypergraph. This, of course means that any information, any data, can become architectonic and habitable and that Cyberspace and cyberspace architecture are one and the same.

A radical transformation of our conception of architecture and the publi domain is implied by cyberspace. The notions of city, square, temple, institution home, infrastructure become permanently extended. The city, traditionally thi continuous city of physical proximity, becomes the discontinuous city of **cul**tural and intellectual community. Architecture, normally understood in the context of the first, conventional city, shifts to the structure of relationships connections and associations that are webbed over and around the simple work of appearances and accommodations of commonplace functions.

I look to my left, and I am in one city; I look to my right, and I am in another. My friends in one can wave to my friends in the other, through my having brought them together.

It is possible to envision architecture nested within architecture. Cyberspace itself is architecture, but it also contains architecture, but now without constraint as to phenomenal size. Cides can exist within chambers as chambers may exist within cides. Since cyberspace signifies the classical object yielding to space and relation, all "landscape" is architecture, and the objects scattered upon the land-scape are also architecture. Everything that was once closed now unfolds into a place, and everything invites one to enter the worlds within worlds it contains.

> I am in an empty park. I walk around a tree, and I find myself in a crowded chamber. The tree is gone. I cali forth a window, and in the distance see the park, leaving.

> That is why we can equally well reject the dualism of appearance and essence. The appearance does not hide the essence, it reveáis it; it is the essence. The essence of an existent is no longer a property sunk in the caviry of this existent; it is the manifest law which presides over the succession of its appearances, it is the principie of the series.
>
> ... But essence, as the principie of the series is definitely only the concatenation of appearances; that is, itself an appearance.
>
> ... The reality of a cup is that it is there and that it is not me. We shall interpret this by saying that the series of its appearances is bound by a principie which does not depend on my whim.
>
> —Jean-Paul Sartre, *Being and Nothingness*

The relationship established between architecture and cyberspace so far is not ^et complete. It is not enough to say that there is architecture in cyberspace, ñor that *that* architecture is animistic or animated. Cyberspace calis us to consider the difference between animism and animation, and animadon and metamorphosis. íVnimism suggests that entítíes have a "spirit" that guides their behavior. Ani-nation adds the capability of change in *location,* through dme. Metamorphosis s change *mform,* through time *or space.* More broadly, metamorphosis implies :hanges in one aspect of an entity as a function of other aspects, continuously or liscontinuously. I use the term liquid to mean animistic, animated, metamor-)hic, as well as crossing categorical boundaries, applying the cognitively super-:harged operations of poetic thinking.

Cyberspace is liquid. Liquid cyberspace, liquid architecture, liquid cities. Liquid architecture is more trian kinetic architecture, robotic architecture, an archi-

Daniel Bandín,
Thomas DeFanti,
and Carolina Cruz-Neira

«27» "A Room with a View" (1993)

CAVE System. Illustration by Milana Huang. Courtesy of Daniel Sundín.

"More *than one user will, however, have to ¡nteract in the same environment if virtual reality is to become an effective visualizationtool."*

« Media artist Daniel Sandin and engineer Thomas DeFanti joined the Electronic Visualization Laboratory at the University of Illinois, Chicago, during the 1970s, where they combined their talents in computer graphics and video imag-ing. Assisted by gradúate student Carolina Cruz-Neira, their research ¡n electronic visualization culminated in 1991 with the design and construction of the CAVE (Cave Automatic Virtual Environment).This paper describes their achievement in advancing the médium of VR by creating a virtual environment that joins in-teractive, computer-generated imagery and 3-D audio with physical space — freeing the user from the confinement of the head-mounted display and dataglove.

The suspensión of disbelief, so critical to the overall effect of virtual reality, is enhanced by the specific qualities of the CAVE's interface, which is, ¡n fact, a small room of about three cubic meters. After entering the room, the user finds himself surrounded by projected images that are seamlessly synchronized on three walls, as well as on the floor. It ¡s like stepping onto the stage of a virtual theater. The participant wears a pair of stereoscopic viewing glasses with built-in head-tracking technology, and carries a "magic wand" that provides the means of manipulating real-time imagery with the subtle movement of the wrist.The immersive experience of the CAVE was intended as an allusion to Plato's cave; its múltiple screens and surround-sound audio evoke the metaphor of a shadowy representation of reality, suggesting how perception is always filtered through .the mind's veil of ¡llusión.

Unlike other systems of virtual reality, the properties of the CAVE are enhanced by the interplay between the real and the virtual. Influenced by Myron Krueger's ¡nstallations, the CAVE ¡mmersant does not experience dislocation and disembodiment, but rather is viscerally aware of his or her physical presence "on stage" amid the animated imagery and orchestrated sound. Also influenced by Krueger, the multiparticipant capability of the CAVE has been extended by networking sepárate CAVE systems together to explore new forms of telematic artworks. »

Xhe media's confidence that virtual reality has already arrived is a little premature (they seem to believe that a set of videogame goggles and gloves is all that is needed). But as recent experience at the Electronic Visualization Laboratory (EVL) of the University of Illinois at Chicago has shown, the technology still needs a good deal of work.

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In pursuit of a practical virtual reality (VR) system, researchers at EVL had to develop sophisticated software apphcations, and real-time networks to link ad-vanced high-speed computers with a variety of high-tech peripherals (such as sound synthesizers and location trackers). In so doing, they had to solve techni-cal problems that had limited the usefulness of such systems.

Real Work The benefits make the development worth the effort. When perfected, virtual reality systems may enhance how people work and play. con-triving comfortable cybernetic environments that enliven and accelerate educa-tion and scientific modeling, in addition to devising new forms of recreation. However, VR is not child's play, as is shown by the Chicago laboratory's strug-gle to get the discrete parts of such systems to function flawlessly together in real time.

The laboratory's virtual reality installation is mostly configured from corar mercially available, state-of-the-art equipment. The installation is called the Cave, which is a recursive acronyrn (that is, an acronym that doubles as one of its own elements) that stands for Cave Automatic Virtual Environment.

While the ñame suggests the system's physical appearance, it is intended more strongly as an allusion to the Allegory of the Cave found in Plato's *Repub-lie.* There the Greek philosopher explored the ideas of perception, reality, and ü-lusion, using the analogy of a person facing the back of a cave alive with shadows that are his only basis for his ideas of what real objects are.

The laboratory's Cave is a new model for the design of virtual reality systems, one that offers severa! advantages over existing models. Unlike users of the video-arcade type of virtual reality system, Cave "dwellers" do not need to wear hel-mets, which would limit their view of and mobility in the real world, ñor don bulky gloves and heavy electronics packs, ñor be pushed about by movement-restricting platforms, to experience virtual reality. Instead, they put on a pair oí lightweight "glasses" and walk into the Cave, a 27-cubic-meter room with an open side and no ceiling.

The Cave is in fact a partial cube, with the top and one vertical side missing, The other three vertical sides are 3-by-3-meter rear-projection screens facing the viewer, while the fioor is a fourth screen—a front-projection one. The screens are wrapped around hard-to-detect cables that form seams at their edges. Behind each screen (or, in the case of the floor screen, above it) is a video projector thal shines stereo images onto it as the viewer stands inside the cube.

The glasses trick a user's mind into seeing the screen images as three-dimensional objects. Each of the glasses' lenses is a shutter made of a liquid-crystal material; an electric pulse rapidly turns the material from clear to opaque or opaque to clear. In this way, each of the viewer's eyes can be momentarily shielded.

Every sixtieth of a second, a pair of stereoscopically different images is projected onto the screen; each of the images that make up the pair (a left-eye view and a right-eye view) is displayed for 1/120 second. The crystal shutters are syn-chronized so that one clears and closes and the other closes and clears 120 times per second. Thus each eye sees a slightly different image, so as to créate the illu-sion of three dimensions.

Note that while the glasses alter what the wearer sees on the screens, they do not change the way he or she sees real objects (or other people) in the environ-ment. Thus, when a computer-generated image of an object is projected into the environment, the viewer may be tempted to ask, "Is it live?" (Well, one just has to try to grasp the object; for now, at any rate, one's hand will pass through a projected image.)

The stereo glasses also have an electromagnetic transmitter attached to them that can be tracked by a location sensor. When the viewer moves, the computers that genérate the images can determine that a change in viewing perspective is needed, and adjust the images appropriately.

A continuous image across several surfaces can be produced when each pro-jector is controlled by a sophisticated computer graphics workstation. Each workstation calcúlales the perspective from each eye position, and sends the data to the projectors.

A hand-held tracking wand with its own location trackers lets the viewer manipúlate the images projected onto the screen. This the person does by locating an imagmary position in virtual reality and interacting with it when the wand "touches" an image. For example, a user can move an object from one place to an-other, select various options from a menú, or strike images of bells and cause them to "ring."

An importan! ingredient in a virtual environment is sound. To genérate the right kind of environmental sounds for whatever application is being run, the Cave employs a synthesizer with a musical-instrument digital interface (MIDI) and up to eight speakers located at the eight corners of the room.

Masterminds The Cave's virtual world is presided over by four Crimson VGX workstations from Silicon Graphics Inc., Mountain View, CA. Each workstation, with 256M-byte memory and two 1.6-gigabyte disks, is connected to an Electrohome Marquee 8000 projection display. A Silicon Graphics Personal Iris serves as a master controller for the system.

All workstations communicate via a ScramNet optical-fiber network from

Systran Corp., Dayton, OH. The network transfers data between these system within the 8-ms window needed to synchronize images displayed on the Cave[1] four screens. It can accurately and synchronously broadcast data in real time i the high speeds necessary.

The workstations display stereo images by dividing the VGX frame buffi into two fields, each of which contains data for the image to be seen by the left a right eye; each field equals half the vertical resolution (1280 by 512 pixels). Th liquid-crystal-shutter glasses (CrystalEyes from StereoGraphics Corp..

Sa Rafael, CA) alternately allow visión in one eye at the field rate of the displays-60 Hz for each eye or 120 Hz combined. The glasses are synchronized b infrared signáis generated by the CrystalEyes controller.

Without the glasses, the wall screens show double images; with them, th viewer gains a striking sense of visual depth and three-dimensional movemenl Although the illusion of motion begins, albeit jerkily, in animation at approxi mately 10 Hz (or 10 frames per second), highly disparate áreas flickered notic* ably even at 30 Hz (60 Hz for both eyes). To avoid that effect, the update rate wa doubledto60Hz(120Hz).

Sound is also provided to enhance the illusion of depth. The use of a soun board and MIDI synthesizers in conjunction with the display allows the cora puter to genérate echoes, Doppler effects, and other sounds associated with rea three-dimensional environments and objects, and to direct them to the appro priate speakers. Thus the system persuades the listener the sound "comes from the proper spot on the horizon.

For the display and sound to créate the best illusion of reality, the systei should be alert to the viewer's location and direction of gaze. Accordingly, ai electromagnetic transponder mounted on the glasses (a Flock of Birds locatioi sensor from Ascensión Technology Corp., Burlington, VT) monitors where th lead viewer's head is inside the Cave and in what direction it is turned. Infol mation on viewer location is sent to the controlling workstation, which does th computations for image generation and sends the data to the appropriate projectors. The hand-held tracking wand also contains a tracking receiver so the syitem can determine where the user is holding and pointing it

Some Advantages While it is much larger than some other approaches. th Cave immerses the user in the virtual reality world. Its high-resolution aro distortion-free wide-angle views are lacking in other systems. Its horizontal resolution OÍ3840 two-by-six-millimeter pixels across three screens is roughly twic that of High-Definition Televisión (HDTV). The visual acuity is about 20/1 Ifl

which is four times better than current head-mounted displays and on a par with binocular omni-oriented monitors (Booms).

The Cave is relatively immune to errors due to head rotation and nodding. With head-mounted displays, the projection plañe must move as the viewer's head moves to look left or right, up or down. Therefore, in head-mounted displays, the viewer must wait for the computer to adjust the monitors accordingly ifter turning, a lag that may cause a loss of equilibrium and even nausea. In the Cave, the projection plañe is stable; a glance to the left inside the Cave shows the image already on-screen.

Also, the Cave is a less intrusive interface. A head-mounted display can be un-:omfortable and disorienting, because the viewer is cut off from the real visual ¡vorld. Someone wearing it is blind to the real-world risks of, say, walking into valls or tripping over the cables needed to connect the headset back to the com-)uter. A viewer in the Cave can move around at will, because the outside world s still visible through the liquid-crystal glasses. Better still, because he or she can tul see the outside world, the Cave frees the viewer to collaborate more fully.

More than one user will, however, have to interact in the same environment f virtual reality is to become an effective visualizaron tool in fields such as reearch and education. While the head-mounted display and the Boom interfaces lo allow múltiple users to share an environment, it is only at the high cost of du-ilicating the interface hardware. The participants must themselves be repre-ented with virtual selves in each other's simulated environments, which adds to system's location-tracking and computational workloads. In other words, in rder for me to see you in a head-mounted display environment, the computer mst calcúlate in virtual terms physically in relation to me and render your image :cordingly on my headset monitors.

In the Cave, two or more users may look around as they wish. They need not e represented virtually, because they represent themselves physically. At present, lough, the screen images are shown from the perspective of only one person, the >-called lead viewer, who is being tracked.

ontinuing Challenges Viewer location tracking remains a challenge. A lag :tween changes in viewer position and the updating of the screen was some-nes noticeable. While less troublesome than the lag experienced with head-ounted displays, it still shows up if the viewer moves too quickly. The lab is oking into extrapolation techniques to better predict user motion and reduce teractive delays to sensor input. More advanced technology may be capable of maintaining several perspectives separately on-screen, so that each viewer enjoys an individual perspective. However, this technological step is not trivial; with each additional viewer, the display update rate increases, and more brightness is required from the projec-tor.

Despite these difficulties, the Cave has drawn long unes of eager would-be vis-itors at industry shows since it was first demonstrated at the showcase event at Siggraph '92, held in Chicago. The applications demonstrated have included practica! and educational programs, such as molecular biology models, superconductor design, fractal mathematics, weather mapping, and environmental management. Some programs were simply entertaining. For example, some visitors had the opportunity to play music with the hand-held wand by ringing bells floating around them.

Other useful applications of the Cave model of virtual reality include scientific visualization, medicine, architecture, and art. In 1994, the Electronic Visualization Laboratory plans to return to Siggraph with an event called Vroom (Virtual Reality Room). The intent is to display the latest in head-mounted displays, binocular omni-oriented monitor, and Cave technologies. The lab is currently asking others for applications to display in the Cave.

At the same time, EVL is also working on the creation of a "road-show" Cave, which would be easier to transport. While this one-of-a-kind working model costs about $600,000 in all, it could eventually become the prototype for home- or business-based Caves that might cost no more than a "home theater" does today.

Lhar Gavies

"Changing Space: Virtual Reality as an Arena of Embodied Being" (1997)

ʳeepondfrom **Osmose.** ***Courtesy ofChar Davies.***

The médium of^immersive virtual space/or virtual ulity-as it ¡s generally known-has intriguing itential as an arena for constructing metaphors about ir existential being-in-the-world and for exploríng wciousness as ¡t is experienced subjectively, as it ¡s '*."

« Canadian artist Char Davies established herself as a painter and filmn before achieving international recognition for pioneering artworks that en the technologies of virtual reality. Her transition to digital media began ¡ míd-1980s, when she first explored how three-dimensíonal computer ¡m¡ techniques could give depth to the traditional picture plañe. In 1987 she ba a founding director of Softimage, a 3-D software company that created sp effects for Hollywood films, including the industry landmark *Jurassíc Park.V* leading the company's visual research team, Davies adopted the Softimage ii ¡ng program for her own artistic purposes. These efforts culminated in tN mersive interactive multimedia work *Osmose,* which premiered atthe Museei contemporain de Montréal in 1995 and has since been shown in museums an the world.

In her paintings, Davies had already expressed an interest in deep-sea di and for the specific ways that people encounter nature. For *Osmose,* Davies her team of engineers devised an innovative interface that evokes deep-sea ing by allowing the user to "float" through a series of virtual worlds.This ir face incorporates the head-mounted display and dataglove, as developed by S Fisher at NASA.To this ensemble Davies's team added sensors that enable userto navigate through breath and balance.This dramatically expanded the in which the participant—or an "immersant," to use Davies's term — Ínter with and inhabits a virtual environment. VVith *Osmose,* she introduced the **fi** tioning of the body as a source for gestural commands in human-computer teraction.This enabled the ¡mmersant to experience a computer-generated sp in an immediate, visceral way —particularly one that evokes otherworldly sc« of nature or compelling abstract settings. As Davies says, her intent is to "n firm the role of the subjectively experienced, *felt' body in cyberspace."

Osmose makes the physical self—rather than the conscious mind—the la for user ¡nteraction. By doing so, Davies allows us to be affected by a virj space in the same subtle way that we are shaped by our unconscious appreh sion of our actual, physical environment. As she quotes from Gastón Bachelai *The Poetry of Space,* "By changing space, by leaving the space of one's usual ser bilities ... we change our nature." Davies's achievement was to incorpórate i intímate, emotional territory of the body ¡nto the encounter with virtual worl Through this work she discovered, as Bachelard suggests, that a shift in en ronment can trigger powerful emotional and psychological responses. »

"Changing Space: Virtual Reality as an Arena of Embodied Beíng"

1 lie médium of "immersive virtual space," or virtual reality—as it is generally mown—has intriguing potential as an arena for constructing metaphors about aur existential being-in-the-world and for exploring consciousness as it is expe-rienced subjectively, as it *isfelt.* Such environments can provide a new kind of "place" through which our minds may float among three-dimensionally extended yet virtual forms in a paradoxical combination of the ephemerally immaterial with what is perceived and bodily felt to be real.

My work as an artist explores VR's capacity for refreshing our "ways of seeing" through the design of immersive virtual environments unlike those of our usual sensibilities. *Osmose* (1994-95) is an interactive, "íully immersive," virtual environment that uses a stereoscopic head-mounted display, three-dimensionally localized interactive sound, and an embodying interface driven by the user's breath and balance. There are nearly a dozen "realms" in *Osmose,* metaphorical reconstructions of "nature" as well as philosophical texts and software code. The visual ciernents within these realms are semitransparent and translucent.[1]

Since mid-1995, more than five thousand people have been immersed in *Osmose.* The overall effect on immersants appears to be quite complex. Many of their responses are surprising in terms of emotional intensity, ranging from eu-phoria to tears of loss. The experience of seeing and floating through things, along with the work's reliance on breath and balance as well as on solitary im-mersion, causes many participants to relinquish desire for active "doing" in favor of contemplative "being." In comparing their reactions with those generated by psychological research into traditionally induced altered states of consciousness, I have come to believe that full-body immersion in an "unusual" virtual environment can potentially lead to shifts in mental awareness. That this may be pos-sible has many implications, some promising, some disturbing.[2]

changing space

Thirty years ago, in *The Poetics of Space,* the philosopher Gastón Bachelard ex-amined the psychologically transformative potential of "real" environments like the desert, the plains, and the deep sea, immense open spaces unlike the urban environments to which most of us are accustomed:

> By changing space, by leaving the space of one's usual sensibilities, one enters into communication with a space that is psychically innovating. For we do not charige place, we change our nature.[3]

Bachelard's poetic insight into the psychological effects of "changing space" is echoed by psychologists documenting the eífects of traditional contemplative practices in terms of altering states of consciousness. According to Arthur Deikman's "Deautomatization and the Mystic Experience," the conditions fostered by such practices involve a dehabituating or "deautomatizing" of perceptual sensi-b ¡lides.

Deautomatization is an undoing of psychic structure permitting the experience of increased detail and sensation at the price of requiring more attention. With such attention, it is possible that deautomatization may permit the awareness of new dimensions of the total stimulus array—a process *oí^perceptual expansión"* ... Deautomatization is here conceived as permitting the adult to attain a new, *fresh* perception of the world by freeing him from a stereotyped organization built up over the years by allowing adult synthetic functions access to fresh materials. The general process of deautomatization would seem of great potential usefulness whenever it is desired to break free from an oíd pattern in order to achieve *a new experience ofthe same stimulus or to open a perceptual avenue to stimuli never experienced befare.*[4] (italics added)

This dehabituating of perception tends to occur as a result of certain psychological conditions, such as when the participant's *attention is intensified* and is directed toward sensory pathways; when there is an absence of controlled, an-alytic thought; and when the participant's attitude is one *ofreceptivity* to stimuli rather than defensiveness or suspicion.[5]

Most often attained through rigorous training in age-old meditation techniques (drug-induced experiences are outside die scope of this essay), such conditions lead to an undoing of habitual perceptions—in favor of alternative sensibilities. While these may be less efficient in terms of biológica! or psychological survival, psychologists believe that they permit experience of aspects of reality previously ignored. The experience of these unusual sensibilities includes:

37. an intense sense of "realness," as when inner stimuli become more realthan objects
38. transcendence of time and space
39. unusual modes of perception
40. feelings of undiñerentiated unity or merging (e.g., a breakdown of distinctions between things and/or the self and the world)
41. ineffability or verbal indescribability

a profound sense ofjoy or euphoria

a paradoxical sense of being in and out of the body[6]

osmose: breathing in and letting Go

These "unusual" sensations are eerily similar to what many people claim they have experienced during immersion in *Osmose.* Among the responses we have gathered through written comments, correspondence, and video interviews, a substantial number of participants have reported the following:

21. a feeling that they had indeed been somewhere else, in another "place"
22. losing track of time (a fifteen-minute session was nearly always experiencedas five, a thirty-minute session as ten)
23. heightened awareness of their own sense of being, or as one immersantdescribed it: "as consciousness embodied, occupying space"[7]
24. adeep sense ofmind/body relaxation
25. an inability to speak rationally or put logical words together afterward
26. a feeling of freedom from their physical bodies and an acute awareness ofthem at the same time
27. intense emotional feelings, including euphoria and/or an overwhelmingsense of loss when the session was ending, causing some to cry and othersto exclaim they were no longer afraid of dying

In addition, we have observed a pattern of behavior among participants during immersion. After becoming accustomed to the interface of breath and balance, most people intent on "doing," traveling around to see as much as possible in what appears to be an extensión of everyday goal-oriented, action-based behavior. After ten minutes or so, however, most undergo a change: their facial ex-pressions and body gestures loosen, and instead of rushing, they slow down, mesmerized by their own perceptions within the space. In this final phase, at-tention seems to be directed toward the unusual sensations of floating and see-ing through things in what becomes a kind of slow-motion perceptual "free-fall."

What is going on here?

If these responses are anything to go by, then it appears that immersive virtual space, as evidenced by *Osmose,* can indeed be "psychically innovating," to use Bachelard's words. Why? The answer lies in the very nature of immersive virtual space. Here, ephemeral virtuality coexists with an apparent three-dimensionality of form, and feelings of disembodiment can coexist with those o! embodiment (given the use of an embodying interface as in *Osmose).* These paradoxical aspects, in combination with the ability to kinesthetically interact with tht elements within the space, créate a veiy unusual experiential context.

I want to emphasize, however, that the medium's perception-refreshing potential is possible only to the extent that a virtual environment is designed to be *unlike* those of our usual sensibilities and assumptions. In *Osmose,* for example, the immersant can unexpectedly see through things and float through them as well. Thus the "familiar" becomes the unusual. This créales room for other modes of perception: instead of the mind being on autopilot it begins to pay attention, in the present, lo whal is unusual and unknown.

osmose: unusual sensibilities

Osmose does not reconstruct ihe world as we habilually perceive il (as empty space containing solid, static, hard-edged, and sepárate objects, with rigid distinctions between subject, object, figure, and ground). Instead, *Osmose* uses transparency and luminous particles to "desolidify" things and dissolve spatial distinctions. When the immersant moves within the space, multiplicities of semi-transparent, three-dimensional forms as well as abstract foreground "flecks"' combine to créate perceptual ambiguity and slippages between figure and ground, near and far, inside and out. Compared to the all too familiar literal representational style commonly associated with three-dimensional computer graphics, this more evocative aesthetic intensifies the perceptual and cognitive process. For the user-interface, a method was developed that relies on the partici-panl's own breath and balance rather than on conventional, hand-oriented meth-ods such as joystick, wand, trackball, or glove—all of which tend to support a distanced and disembodied stance toward the world. This approach, based on breathing in to rise, out to fall, and leaning to change direction, brings the experience inward, "grounding" it within the core of ihe participant's physical body. Conceplually informed by ihe scuba diver's practice of buoyancy control, this hands-off technique "frees" participante from the urge to handle and control the world of "objects."[8] This approach was intended to "reaffirm" the role of the subjeclively experienced, "felt" body in cyberspace, in direct contrast to its usual absence or objectification in virtual worlds. The use of breathing and balance also tends to deeply relax people, creating a tranquil state of mind and body

The feelings reported by various parücipants were probably intensified by the solitary nature of the experience, as well as by the fact that the work is "fully immersive" (its space is perceived as totally enveloping, due to our use of a wide-field-of-view head-mounted display). These aspects, in combination with the three-dimensionality of the work and the fluid, interactive sound, act to amplify the embodied yet virtual nature of the experience.

While the psychological eífects of full-body immersion in a computer-generated virtual environment like *Osmose* have yet to be scientifically analyzed, the potential of the médium to dehabituate our sensibilities and allow for a re-sensitization of the perception of being invites further exploration.

implications

Not to be forgotten is the possibility of the medium's potency being used to replace bodily experiences of the "real" with phantasms of virtual utopias. In her preface to *Rethinking Technologies,* Verona Conley writes about our loss of"hu-manness" in the wake of the world "becoming technological."[9]

> In view of the grim prospect of the twenty-first century, we are compelled to ask how critics of culture, philosophers, and artists will deal with technologies. How do they contend with expansionist ideology, and the accelerated elimination of diversity and of singularities? How do they resist or act? . .. Now, in a world where the notion of space has been completely changed through electronic si-multaneity, where the computer appears to go faster than the human brain, or where "virtual reality" replaces "reality," how do philosophy, critical theory, or artistic practices deal with those shifts?[10]

This question aptly applies to immersive virtual space, especially when one considers that it will one day likely be used for such (questionable) purposes as adapting individuáis to psychological and biological survival in a less and less "user-friendly" living environment. Moreover, unlike Bachelard's desert or deep sea, Deikman's meditation cell, or even an isolation tank, VR is a communicative médium, which by default carnes conventional cultural valúes of the Western technoscientific worldview from which that technology has sprung.

The beginnings of an answer to Conley's question may have been formulated by Martin Heidegger more than fifty years ago in *The Question Concerning Technology.* As an alternative to what he called technology's tendency to fiínction as an instrument of domination and control, Heidegger pointed to an earlier form of "techne" called "poiesis" by the Greeks, associated not with "challenging" but with a "bringing-forth" or "revealing" into presence. The Greeks considered this artistic activity to be somewhat equivalen! to what they called *physis,* or na-ture's own bursting forth of being.[11]1 find inspiration here in terms of the use of immersive virtual space as a médium for "bringing forth" or "manifesting" ab- • stract ideas into the realm of virtual "place" so that they can be kinesthetically ex- j plored and bodily lived.

This may prove to be a promising use of the médium, and, given effective subversión of its culturally bound characteristics, may be a step toward suggesting alternative ways of seeing and being in the world. However, even so, there remains a significantly disheartening aspect. For even as "places" like *Osmose* may one day be accessible on line as virtual sites of contemplation, so too such sites may sig-nal the demise of traditional places of self-reflection and tranquillity. In particular this includes "nature" as we know it, as compromised in body and habitat by human activities, nature's unfathomable presences recede íurther and further from our urban lives. My own practice in the field of "virtual reality" thus con-tains a bittersweet aspect, entangled in feelings of both longing and loss.

1.

partV

Narratívíty

William Burroughs

The Future oFthe Novel" (1964)

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William Burroughs and Brion Gysin. Copyright © 1978 William S. Burroughs andBrion Gysin, reprinted with the permission ofThe Wylie Agency, Inc.

'Certainly if writing is to have a Mure it must at least catch up with the past and learn to use techniques that have been used for some time past in painting, music and film."

« William Burroughs, appropriately the grandson of the inventor of the ad machine, was a catalyst in instigating the literary movement surroundingl emerging digital culture in the 1980s through his surreal mythologies of aliel fluence and space-age futurisms.Yet it was Burroughs's preoccupation witfl deconstruction of words and language, most notably through the cut-up fold-in techniques that he developed with artist Brion Gysin beginning in H which constitutes his most significant contribution to the fragmentary, nonlii approach to contemporary narrative—from the cyberpunk novel to the 6 tronically mediated hypertext.

In this essay Burroughs describes the cut-up technique he developed *i* completing his novel *Naked Lunch* in the late fifties, and later implemented ¡i famous trilogy *The Soft Machine, The Ticket That Exploded,* and *Nova*

Express. His in was to find a way, through writing, to explore nonlinear perceptions of space time. Burroughs viewed the cut-up as a way for the writer to discover new i nections that extended and ultimately dissolved the rational associations of i ventional narrative. Borrowing from the collage technique of visual artists, *t* notably the surrealists, his method links fragments of texts in surprising ju positions, offering unexpected leaps into uncharted territories. For this rea Burroughs refers to himself as ^{u}a map maker, an explorer of psychic áreas.

Burroughs's writing experiments of íhe early 1960s express the esseí narrative strategies of computer-based multimedia storytelling long beforel time. He regards the reading experience as one of entering into a multidirecti web of different voices, ideas, perceptions, and periods of time. This kind of i igation echoes the work of Vannevar Bush, Douglas Engelbart, and Ted Nel who used personal association as a guiding principie for the organizaron a formation, and proposed hypermedia systems that would make prívate, ass< tive thinking accessible to others. For Burroughs, narrative operates as a j multithreaded network that reflects the associative tendencies of the mind.

In my writing I am acting as a map maker, an explorer of psychic áreas, to the phrase of Mr Alexander Trocchi, as a cosmonaut of inner space, and I se point in exploring áreas that have already been thoroughly surveyed—A Rm scientist has said: "We will travel not only in space but in time as well—" TI to travel in space is to travel in time—If writers are to travel in space time am plore áreas opened by the space age, I think they must develop techniques quite as new and definite as the techniques of physical space travel—Certainly if writ-ing is to have a future it must at least catch up with the past and learn to use techniques that have been used for some time past in painting, music and film—Mr Lawrence Durrell has led the way in developing a new form of writing with time and space shifts as we see events from different viewpoints and realize that so seen they are literally not the same events, and that the oíd concepts of time and real-ity are no longer valid—Brion Gysin, an American painter living in París, has used what he calis "the cut-up method" to place at the disposal of writers the collage used in painting for fífty years—Pages of text are cut and rearranged to form new combinations of word and image—In writing my last two novéis, *Nova Express* and *The Ticket That Exploded,* I have used an extensión of the cut-up method I cali "the fold-in method"—A page of text—my own or someone else's—is folded down the middle and placed on another page—The composite text is then read across half one text and half the other —The fold-in method extends to writing the flashback used in films, enabling the writer to move backward and forward on his time track—For example I take page one and fold it into page one hun-dred—I inserí the resulting composite as page ten—When the reader reads page ten he is flashing forward in time to page one hundred and back in time to page one—the *deja vu* phenomenon can so be produced to order—This method is of course used in music, where we are continually moved backward and forward on the time track by repetition and rearrangements of musical themes—

In using the fold-in method I edit, delete and rearrange as in any other method of composition—I have frequently had the experience of writing some pages of straight narrative text which were then folded in with other pages and found that the fold-ins were clearer and more comprehensible than the original texts—Perfectly clear narrative prose can be produced using the fold-in method— Best results are usually obtained by placing pages dealing with similar subjects njuxtaposition—

What does any writer do but choose, edit and rearrange material at his disposal?— The fold-in method gives the writer literally infinite extensión of :hoice—Take for example a page of Rimbaud folded into a page of St John Jerse—(two poets who have much in common)—From two pages an infinite lurnber of combinations and images are possible—The method could also lead o a collaboration berween writers on an unprecedented scale to produce works hat were the composite effort of any number of writers living and dead —This tappens in fact as soon as any writer starts using the fold-in method —I have

made and used fold-ins from Shakespeare, Rimbaud, from newspapers, magazines, conversations and letters so that the novéis I have written using this method are in fact composites of many writers—

I would like to emphasize that this is a technique and like any technique will, of course, be useful to some writers and not to others—In any case a matter foi experimentation not argument—The conferring writers have been accused by th« press of not paying sufficient attention to the question of human survival—Ir *Nova Express* (reference is to an exploding planet) and *The Ticket That Exploded,* I am primarily concerned with the question of survival—with nova conspiracies, nova criminâis, and nova pólice—A new mythology is possible in the space ag« where we will again have héroes and villains with respect to intentions toward thi¡ planet—

Alian Kaprow

"Untitled Guidelines Por Happenings" (1965)

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Alian Kaprow,* Household. *Photo by Sol Goldberg. © Sol Goldbarg.

"The images in each sítuation can be quite disparate: a kitchen ¡n Hoboken, a pissoir *in París, a taxi garage in Leopoldville, and a bed in some small town in Turkey... None ofthese planned ties are absolutely required, for preknowledge ofthe Happening's cluster ofevents by all partidpants will al I ow each one to make his own connections."*

« Alian Kaprow ¡s best known as a prime mover behind the Happenings. H coined the term ¡n the late 1950s, and led the movement into the bright lights i popular culture that characterized the 1960s. Happenings are notoriously difl cult to describe, ¡n part because each was a unique event shaped by the actio» of the audience that participated ¡n any given performance. Simply put, Haj penings were held in physical environments—loft spaces, abandoned factorie buses, parks, etc.—and brought people, objects, and events ¡n surprising juxt position to one another. With the Happenings, Kaprow rejected the authori and primacy of the artwork as an idealized creation and holy act. Rather, he viei art as a vehicle for expanding our awareness of life by prompting unexpecte provocative interactions. For Kaprow, art is a continual work-in-progress, **wi** an unfolding narrative that is realized through the active participation of the a dience.

In this essay, Kaprow sets down guidelines for creating Happenings. He t gins by dissolving the boundaries between art and everyday life, distributing i sponsibility for the execution of the performance to all of ¡ts participants. Jo Cage's ¡nfluence was important to Kaprow's work, particularly the compose interest ¡n ¡ndeterminacy, chance operations, and audience ¡nvolvement. Cacj experimental performances at Black Mountain College ¡n the late 1940s are i garded as proto-Happening events. Kaprow's approach actually attempted elimínate the distinction between audience and performer all together.

Kaprow developed techniques to prompt a creative response from the au ence, encouraging audience members to make their own connections betwe ¡deas and events.These narrative strategies relied on a nonlinear sequencing events, and the use of ¡ndeterminacy to shape the course of the Happenii Kaprow describes how a Happening might take place over an extended peri across vast distances, or ¡n many places at once. His techniques reordered pz present, and future within a single work ¡n a remarkable variety of arran ments.The decentralization of authorship, location, and narrative—here uní by the intent of the artist and the ¡magination of the participating audiei members—foreshadows nonlinear forms in digital media that make use of ¡nj active and networked technology to expand the boundaries of space and time.

(A) *The Une between art and life should be kept as/luid, andperhaps indisti as possible.* The reciprocity between the man-made and the ready-made **wil** at its máximum potential this way. Something will always happen at this junct

which, if it is not revelatory, will not be merely bad art—for no one can easily compare it with this or that accepted masterpiece. I would judge this a foundation upon which may be built the specific criteria of the Happenings.

(B) *Therefore, the source ofthemes, materiak, actions, and the relationships between them are to be derivedfrom any place or period exceptfrom the arts, their derivatives, and their milieu.* When innovations are taking place it often becomes necessary for those involved to treat their tasks with considerable severity. In order to keep their eyes fixed solely upon the essential problem, they will decide that there are certain "don'ts" which, as self-imposed rules, they will obey unswervingly. Arnold Schoenberg felt he had to abolish tonality in music composition and, for him at least, this was made possible by evolving the twelve-tone series technique. Later on his more academic followers showed that it was very easy to write traditional harmonies with that technique. But still later,John Cage could permit a C major triad to exist next to the sound of a buzz saw, because by then the triad was thought of differently—not as a musical necessity but as a sound as interesting as any other sound. This sort of freedom to accept all kinds of subject matter will probably be possible in the Happenings of the future, but I think not for now. Artistic attachments are still so many window dressings, unconsciously held on to to legitimize an art that otherwise might go unrecognized.

Thus it is not that the known arts are "bad" that causes me to say "Don't get near them": it is that they contain highly sophisticated habits. By avoiding the irtistic modes there is the good chance that a new language will develop that has ts own standards. The Happening is conceived as an art, certainly, but this is for ack of a better word, or one that would not cause endless discussion. I, personilly, would not care if it were called a sport. But if it is going to be thought of in he context of art and artists, then let it be a distinct art which finds its way into he art category by realizing its species outside of "culture." A United States Maine Corps manual onjungle-fighting tactics, a tour of a laboratory where polythylene kidneys are made, the daily trafficjams on the Long Island Expressway, re more useful than Beethoven, Racine, or Michelangelo.

C) *The performance ofa Happening should takeplace overseveral widely spaced, nnetimes moving and changing locales.* A single performance space tends toward ie static and, more significantly, resembles conventional theater practice. It is so like painting, for safety's sake, only in the center ofa canvas. Later on, when e are used to a fluid space as painting has been for almost a century, we can re-irn to concentrated áreas, because then they will not be considered exclusive, is presently advantageous to experiment by gradually widening the distances between the events within a Happening. First along several points on a heai trafficked avenue; then in several rooms and floors of an apartment house wfo some of the activities are out of touch with each other; then on more than o street; then in difFerent but proximate cities; finally all around the globe. On I one hand, this will increase the tensión between the parts, as a poet might stretching the rhyme from two lines to ten. On the other, it permits the parta exist more on their own, without the necessity of intensive coordination. Re tionships cannot help being made and perceived in any human action, and h< they may be of a new kind if tried-and-true methods are given up.

Even greater flexibility can be gotten by moving the lócale itself. A Happx ing could be composed for a jetliner going from New York to Luxembourg w stopovers at Gander, Newfoundland, and Reykjavik, Iceland. Another Happn ing would take place up and down the elevators of five tall buildings in midtoi Chicago.

The images in each situation can be quite disparate: a kitchen in Hobokei *pissoir* in Paris, a taxi garage in Leopoldville, and a bed in some small town Turkey. Isolated points of contact may be maintained by telephone and letters, a meeting on a highway, or by watching a certain televisión program at an appoinl hour. Other parts of the work need only be related by theme, as when all locales p form an identical action which is disjomed in timing and space. But none of thi planned ties are absolutely required, for preknowledge of the Happening's clus of events by all participants will allow each one to make his own connections. TTi however, is more the topic of form, and I shall speak further of this shortly.

(D) *Time, which follows closely on space considerations, should be variable and ¿ continuous.* It is only natural that if there are múltiple spaces in which oca rences are scheduled, in sequence or even at random, time or "pacing" w acquire an order that is determined more by the character of movements witl environments than by a íixed concept of regular development and conclusic There need be no rhythmic coordination between the several parts of a Ha pening unless it is suggested by the event itself: such as when two persons mi meet at a train departing at 5:47 P.M.

Above all, this is "real" or "experienced" time as distinct from concepti time. If it conforms to the clock used in the Happening, as above, that is legi mate, but if it does not because a clock is not needed, that is equally legitima All of us know how, when we are busy, time accelerates, and how, convers* when we are bored it can drag almost to a standstill. Real time is always connect with doing something, with an event of some kind, and so is bound up wi things and spaces.

Imagine some evening when one has sat talking with friends, how as the con-versation became reflective the pace slowed, pauses became longer, and the speakers "felt" not only heavier but their distances from one another increased proportionately, as though each were surrounded by great áreas commensurate with the voyaging of his mind. Time retarded as space extended. Suddenly, from out on the street, through the open window a pólice car, siren whining, was heard speeding by, *its* space moving as the source of sound moved from somewhere to the right of the window to somewhere farther to the left. Yet it also carne spilling into the slowly spreading vastness of the talkers' space, invading the transformed room, partly shattering it, sliding shockingly in and about its envelope, nearly dis-placing it. And as in those cases where sirens are only sounded at crowded street corners to warn pedestrians, the pólice car and its noise at once ceased and the capsule of time and space it had become vanished as abruptly as it made itself felt. Once more the protracted picking of one's way through the extended reaches of mind resumed as the group of friends continued speaking.

Feeling this, why shouldn't an artist program a Happening over the course of several days, months, or years, slipping it in and out of the performers' daily lives. There is nothing esoteric in such a proposition, and it may have the distinct advantage of bringing into focus those things one ordinarily does every day with-out paying attention—like brushing one's teeth.

On the other hand, leaving taste and preference aside and relying solely on chance operations, a completely unforeseen schedule of events could result, not merely in the preparation but in the actual performance; or a simultaneously performed single moment; or none at all. (As for the last, the act of finding this out would become, by default, the "Happening.")

But an endless activity could also be decided upon, which would apparently transcend palpable time—such as the slow decomposition of a mountain of sand-stone.... In this spirit some artists are earnestly proposing a lifetime Happening equivalen! to Clarence Schmidt's lifetime Environment.

The common function of these alternatives is to reléase an artist from conventional notions of a detached, closed arrangement of time-space. A picture, a piece of music, a poem, a drama, each confined within its respective frame, fixed number of measures, stanzas, and stages, however great they may be in their own right, simply will not allow for breaking the barrier between art and life. And this ís what the objective is.

[E) *Happenings should be performed once only.* At least for the time being, this re-striction hardly needs emphasis, since it is in most cases the only course possi-ale. Whether due to chance, or to the lifespan of the materials (especially the perishable ones), or to the changeableness of the events, it is highly unlikely th¡ a Happening of the type I am outlining could ever be repeated. Yet many of ti Happenings have, in fact, been given four or five times, ostensibly to accomrru date larger attendances, but this, I believe, was only a rationalization of the wis to hold on to theatrical customs. In my experience, I found the practice inadi quate because I was always forced to do that which *could be* *repeated,* and had I discard countless situations which I felt were marvelous but performable onl once. Aside from the fact that repetition is boring to a generation brought up o ideas of spontaneity and originality, to repeat a Happening at this time is to ai cede to a far more serious matter: compromise of the whole concept of Chang When the practical requirements of a situation serve only to kill what an artist h¡ set out to do, then this is not a practical problem at all; one would be very pra tical to leave it for something else more liberating.

Nevertheless, there is a special instance of where more than one performaru is entirelyjustified. This is the score or scenario which is designed to make eveí performance significantly diíferent from the previous one. Superficially this h¡ been truc for the Happenings all along. Parts have been so roughly scored th there was bound to be some margin of imprecisión from performance to perfo manee. And, occasionally, sections of a work were left open for accidentáis or ii provisations. But since people are creatures of habit, performers always tendc to fall into set patterns and stick to these no matter what leeway was given the in the original plan.

In the near future, plans may be developed which take their cue from gara and athletics, where the regulations provide for a variety of moves that make ti outcome always uncertain. A score might be written, so general in its instructioi that it could be adapted to basic types of terrain such as oceans, woods, cirie farms; and to basic kinds of performers such as teenagers, oíd people, childre matrons, and so on, including insects, animáis, and the weather. This could 1 printed and mail-ordered for use by anyone who wanted it. George Brecht h been interested in such possibilities for some time now. His sparse scores rea like this:

Direction

Arrange to observe a sign indicating direction of travel.

3. travel in the indicated direction
4. travel in another direction

But so far they have been distributed to friends, who perform them at their discretion and without ceremony. Certainly they are aware of the philosophic allusions to Zen Buddhism, of the subtle wit and childlike simplicity of the activities indicated. Most of all, they are aware of the responsibility it places on the performer to make something of the situation or not.

This implication is the most radical potential in all of the work discussed here. Beyond a small group of initíates, there are few who could appreciate the moral dignity of such scores, and fewer still who could derive pleasure from going ahead and doing them without self-consciousness. In the case of those Happenings with more detailed instructions or more expanded action, the artist must be present at every moment, directing and participating, for the tradition is too young for the complete stranger to know what to do with such plans if he got them.

(F) *Itfollows that audiences should be eliminated entirely.* All the elements—peo-ple, space, the particular materials and character of the environment, time—can in this way be integrated. And the last shred of theatrical convention disappears. For anyone once involved in the painter's problem of uniíying a field of divergent phenomena, a group of inactive people in the space of a Happening is just dead space. It is no different from a dead área of red paint on a canvas. Movements cali up movements in response, whether on a canvas or in a Happening. A Happening with only an empathic response on the part of a seated audience is not a Happening but stage theater.

Then, on a human plañe, to assemble people unprepared for an event and say that they are "participating" if apples are thrown at them or they are herded about is to ask very litde of the whole notion of participation. Most of the time the response of such an audience is half-hearted or even reluctant, and sometímes the reaction is vicious and therefore destructive to the work (though I suspect that in numerous instances of violent reaction to such treatment it was caused by the latent sadism in the action, which they quite rightly resented). After a few years, in any case, "audience response" proves to be so predictably puré cliché that anyone serious about the problem should not tolérate it, any more than the painter should continué the use of dripped paint as a stamp of modernity when it has been adopted by every lampshade and Fórmica manufacturer in the country.

I think that it is a mark of mutual respect that all persons involved in a Happening be willing and committed participants who have a clear idea what they are to do. This is simply accomplished by writing out the scenario or score for all and discussing it thoroughly with them beforehand. In this respect it is not different from the preparations for a parade, a football match, a wedding, or religious ser-vice. It is not even different from a play. The one big diñerence is that while knowledge of the scheme is necessary, professional talent is not; the situations in a Happening are lifelike or, if they are unusual, are so rudimentary that profes-sionalism is actually uncalled for. Actors are stage-trained and bring over habita from their art that are hard to shake off; the same is true of any other kind of show-man or trained athlete. The best participants have been persons not normally en-gaged in art or performance, but who are moved to take part in an activity that is at once meaningíul to them in its ideas yet natural in its methods.

There is an exception, however, to restricting the Happening to participants only. When a work is performed on a busy avenue, passers-by will ordinarib stop and watch, just as they might watch the demolition of a building. These are not theater-goers and their attention is only temporarily caught in the course o! their normal affairs. They might stay, perhaps become involved in some unex-pected way, or they will more likely move on after a few minutes. Such persoru are authentic parts of the environment.

A variant of this is the person who is engaged unwittingly with a performei in some planned action: a butcher will sell certain meats to a customer-performei without realizing that he is a part of a piece having to do with purchasing, coofc ing, and eating meat.

Finally, there is this additional exception to the rule. A Happening may b< scored *íorjust watching.* Persons will do nothing else. They will watch things each other, possibly actions not performed by themselves, such as a bus stoppinjto pick up commuters. This would not take place in a theater or arena, but anywhere else. It could be an extremely meditative occupation when done devotedryjust "cute" when done indifferently. In a more physical mood, the idea of calledfor watching could be contrasted with periods of action. Both normal tendencieto observe and act would now be engaged in a responsible way. At those momentof relative quiet the observer would hardly be a passive member of an audiencehe would be closer to the role of a Greek chorus, without its specific mearánnecessarily, but with its required place in the overall scheme. At other momentthe active and observing roles would be exchanged, so that by reciprocation thwhole meaning of watching would be altered, away from something like spoonfeeding, toward something purposive, possibly intense

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« Since he began producing video art ¡n the early 1970s, Bill Viola ha; plored ways to manipúlate and restructure our perception of time and s| through electronic media. After several years of creating single-channel work videotape; ¡n which he explored the restructuring of time through techniques extreme slow motion, jarring edits, and surreal superimpositions, Viola beg« project video onto surfaces, which introduced a spatial element to his inst tions. In 1982, the same year that Lynn Hershman released the first videodisc, *Loma,* Viola wrote this article about the narrative potential of ii active media. Here he discusses the concept of *dataspace, a* territory of infoi tion in which all data exists in a continual present, outside the traditi definitions of time and space, available for use in endless juxtapositions.

Viola arrives at the notion of dataspace by considering the spaces that I been constructed over the ages to record cultural history in architectural **fi** from Greek temples to Gothic cathedrals. He compares these "memory pala to the personal computer, with its capacity for storage, instant access, aro formation retrieval. Cathedrals, Viola says, communicate through their syml ornamentation, ¡llustrative paintings, and stained-glass narratives. Similarlj branching pathways and forking paths of computer-controlled video works be explored by the viewer searching for story and meaning. As Viola explains, ability to enter a nonlinear ¡nformation matrix at any point, to navigate its tents freely in any direction and at any speed, introduces a kind of "¡dea sp¡ where the only constraint is the limit of the human ¡magination.The computei ¡ntroduced the "next evolutionary step," Viola claims, in which ancient me of memory and artistic expression are reborn through the fluid processes a formation technologies. »

will there be condominiums in data space?

Possibly the most startling thing about our individual existence is that it is i tinuous. It is an unbroken thread—we have been living this same moment since we were conceived. It is memory, and to some extent sleep, that gives u impression of a life of discrete parts, periods, or sections, of certain time "highlights." Hollywood movies and the media, of course, reinforce this ception.

If thmgs are perceived as discrete parts or elements, they can be rearran

Gaps become most interesting as places of shadow, open to projection. Memory can be regarded as a filter (as are the five senses)—it is a device implanted for our survival. The curse of the mnemonist is the flood of images that are constantly re-playing in his brain. He may be able to demónstrate extraordinary feats of recall, but the rest of the banal and the mundane is playing back in there too, endlessly. The result can be lack of sleep, psychosis, and even willful death, driving some to seek professional psychiatric help (and thus become history on the pages of medicaljournals and books).[1] This reincarnates one of the curses of early video art—"record everything," the saturation-bombing approach to Ufe which made so many early video shows so boring and impossible to sit through. Life without editing, it seems, is just not that interesting.

It is only very recently that the ability to forget has become a prized skill. In the age of "information overload," we have reached a critical mass that has ac-celerated the perfection of recording technologies, an evolution that leads back to ancient times. Artificial memory systems have been around for centuries. The early Greeks had their walks through temple,[2] and successive cultures have re-fined and developed so-called "mnemo-technics"—Thomas Aquinas described an elabórate memory scheme of projecting images and ideas on places; in 1482 Jacobus Publicius wrote of using the spheres of the universe as a memory system; Giulio Gamillo created a "Memory Theater" in Italy in the early 1500s; and Giordano Bruno diagrammed his system of artificial memory in his work *Shad-ows,* published in 1582. Francés Yates describes this entire remarkable área in her brilliant book *The Art of Memory* (University of Chicago Press, 1966).

When I was in Japan in 1981,1 visited a festival of the dead at one of the most sacred places in the country, Osoresan Mountain. There I saw blind female shamen called *itako* calling back the spirits of the dead for inquiring relatives, a centuries-old practice. Until that time I had felt that the large Japanese electron-ics companies were way ahead in the development of Communications technol-ogy. After witnessing the *itako,* however, I realized they were way behind. Right in their own backyard were people who, without the aid of wires or hardware of any sort, have been for ages regularly communicating through time and space with ancestors long gone. An interesting place at the temple site (which was perched in the surreal landscape of an extinct volcanic cráter) was a special walk for the visiting pilgrims to take along a prescribed trail. The way led from the temple through a volcanic wasteland of rockpiles and smoking fissures to the shores of a cráter lake. It was called "the walk through Hell." The path through the landscape and the points along it all had special significance. The *itako,* to cali up the dead, took this "walk through Hell" in their minds, bringing the spirits in

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along the familiar path, and when they were through, sent them back the sam< way.

The interesting thing about idea spaces and memory systems is that they pre-suppose the existence of some sort of place, either real or graphic, which has iti own structure and architecture. There is always a whole space, which already ex-ists *in its entirety,* onto which ideas and images can be mapped, using only thal portion of the space needed.

In addition to the familiar model of pre-recorded time unfolding along a linear path (as evidenced by many things, from our writing system to the thread oí magnetic tape playing in a videotape recorder), there is another parallel to be linked with modern technology. "Data space" is a term we hear in connection with computers. Information must be entered into a computer's memory to créate a set of parameters, defining some sort of ground, or field, where future cal-culations and binary events will occur. In three-dimensional computer graphics. this field exists as an imaginary but real chunk of space, a conceptual geometry, theoretically infinite, within which various forms may be created, manipulated, extended, and destroyed. The graphics display screen becomes that mysterious third point of view looking in on this space (we often cali it our "mind's eye"), which can be moved about and relocated from any angle at will. The catch is thal the space must exist in the computer first, so that there is a reference system within which to lócate the various coordinates of points and lines called into being by the operator. In our brain, constantly flickering pulses of neuron firings créate a steady-state field onto which disturbances and perturbations are regis-tered as percepts and thought forms. This is the notion that something is already "on" before you approach it, like the universe, or like a video camera which always needs to be "video-ing" even if there is only a blank ráster ("nothing") to see. Turn it ofF, and it's not video anymore.

When I had my first experience with computer videotape editing in 1976, one demand this new way of working impressed upon me has remained significanL It is the idea of holism. I saw then that my piece was actually finished and in existence *before* it was executed on the VTRs. Digital computers and software tech-nologies are holistic; they think in terms of whole structures. Wordprocessors allow one to write out, correct, and rearrange the *whole* letter before typing it. Data space is fluid and temporal, hardcopy is for real—an object is born and becomes fixed in time. Chiseling in stone may be the ultimate hard copy.

When I edited a tape with the computer, for the first time in my Ufe I saw that my video piece had a "score," a structure, a pattern that could be written out on paper. We view video and film in the present tense—we "see" one frame at a time passing before us in this moment. We don't see what is before it and what is after it—we only see the narrow slit of "now." Later, when the lights come on, it's gone. The pattern does exist, of course, but only in our memory. Notation sys-tems have been around since the beginning of history, since what we cali history *is* notation of events in time, i.e., historical "records." With speech we have graphic writing systems; with music we have the score. They are both symbolic coded systems for the recording and later playback of information events in time. Poetry has always had a level that video or film cannot approach (at least not yet): the existence of the words on paper ^how the poem looks, how the words are placed on the page, the gaps, the spacing, etc.). The whole poem is there before us, and, starting at the top of the page, we can see the end before we actually get there.

Our cultural concept of education and knowledge is based upon the idea of building something up from a ground, from zero, and starting piece by piece to put things together, to construct edifices. It is additive. If we approach this process from the other direction, considering it to be backwards, or subtractive, all sorts of things start to happen. Scientists always marvel at nature, at how it seems to be some grand code, with a built-in sense of purpose. Discoveries are made which reveal that more and more things are related, connected. Everything appears to be aware of itself and everything else, all fitting into an interlocking whole. We quite literally carve out our own realities. If you want to make a jigsaw puzzle, you must first start with the whole image, and *then* cut it up. The observer, working backwards into the system, has the point of view that he or she is building things up, putting it together piece by piece. The prophet Mohamed has said, "All knowledge is but a single point—it is the ignorant who have multiplied it."

the whole Is the sum of its parts

A friend of mine is an ethnomusicologist who spent several years studying the gamelan music of Central Java. He was trained in Western music in the States, and spent many years working on his own compositions and performing with other musicians. One of the most frustrating things about his studies injava, he told me, was trying to work on specific parts of songs with the gamelan musicians. Once they were at a rehearsal, and after running through a piece, he asked them to *play* only *a* section from the middle so that he could make sure he got all the notes right. This preved to be an impossible request. After a lot of hemming and hawing, excuses, and several false starts, he realized that the group just could not do it. They insisted on playing the entire piece over again, from beginning to end. In Java, the music was learned by rote, from many years of observation and imitation, not from written notation. The idea of taking a small part out of con-text, or playing just a few bars, simply did not exist. The music was learned and conceived as a whole in the minds of the musicians.

Giulio Paolini, the contemporary Italian artist, made a little-known but fai reaching videotape in the mid-seventies. It was bis first and only tape. Workin at an experimental video studio in Florence in the eradle of Western art, he, lil many other European artists who visited the art/tapes/22 studio, had bis first ei counter with video. Instead of simply re-translating into video what he had a ready been doing before, as most other artists had done, Paolini intuitivd recognized the great power underlying the recording media. He took the slid< of all bis work, most of the pieces he had ever made, and recorded them one at time on each frame of video. Playing back this tape, the viewer sees 15 years < Paolini's art, bis life's work, go by in less than a minute. Poof! It's gone.

It is slowly becoming clear that structuralism, currently out of fashion in ti fashion-conscious, ever shifting spodight of the art world, must be reconsidere» It is vital. However, this new structuralism is not the same as the often ova intellectualized, didactic, structuralism-for-structuralism's-sake that took cenü stage in the art scene over a decade ago (most visibly through the work of e: perimental filmmakers). In retrospect, however, the core ideas being expresse dien certainly remain importan!, and perhaps could only have emerged in *the* wj they did given that particular place and moment in cultural time. Furdiermor the anü-content messages that have been espoused in various fields of art in ti twentieth century also continué to merit attention. We have all been made awai diat, since the Renaissance, Western eyes have been drawn to Üie visual, to ti surface appearance of the world. "Realism" carne to mean how something a] peared to the eye alone. Looking at the Gothic art before it, along with Asían an so-called Primitive or Tribal Art, it is clear that something fundamental is mis ing. However, from our viewpoint today, it is also clear that puré structuralis alone is no answer either.

Decadent art is simply an art which is no longer felt or energized, but merely denotes, in which there exists no longer any real correspondence between the formal and pictorial elements, its meaning, as it were, negated by the weakness or incongruity of the pictorial element; but it *is* often.. *.far kss* conventional than are the primitive or classic stages of the same sequence. True art, puré art, never enters into competition with the unattainable perfection of the world.[3]

—A. K. Coomaraswamy

Structure, or form, has always been the basis of the original pictorial art of both Europe and the East, but the Middle Ages were the last time when both Eu-rope and Asia met on common artistic ground.

> In Western art, the picture is generally conceived as seen in a frame or through a window, and so brought towards the spectator; but the Oriental image really exists only in our mind and heart and thence is projected or reflected into space.
>
> The Indian, or Far Eastern icón, carved or painted, is neither a memory image ñor an idealization, but a visual symbolism, ideal in the mathematical sense.... Where European art naturally depicts a moment of time, an arrested action, or an effect of light, Oriental art represents a continuous condition. In traditional European terms, we should express this by saying that modern European art endeavors to represent things as they are in themselves, Asiatic and Christian art to represent things more nearly as they are in God, or nearer their source.
>
> —A. K. Coomaraswamy

The idea of art as a kind of diagram has for the most part not made it down from the Middle Ages into modern European consciousness. The Renaissance was the turning point, and the subsequent history of Western art can be viewed as the progressive distancing of the arts away from the sacred and towards the profane. The original structural aspect of art, and the idea of a "data space" *was* pre-served through the Renaissance, however, in the continued relation between the image and architecture. Painting became an architectural, spatial form, which the viewer experienced by physically walking through it. The older concept of an idea and an image architecture, a memory "place" like the mnemonic temples of the Greeks, is carried through in the great European cathedrals and palaces, as is the relation between memory, spatial movement, and the storage (recording) ofideas.

Something extraordinary is occurring today, in the 1980s, which ties together all these threads. The computer is merging with video. The potential offspring óf this marriage is only beginning to be realized. Leaping directly into the farther fu-ture for a moment, we can see the seeds of what some have described as the ultímate recording technology: total spatial storage, with the viewer wandering

through some three-dimensional, possibly life-sized field of prerecorded or sil ulated scenes and events evolving in time. At present, the interactive video día currently on the market have already begun to address some of these possibi ties. Making a program for interactive video disc involves the ordering and stru turing (i.e., editing) of much more information than will actually be seen by ¡ individual when he or she sits down to play the program. All possible pathwai or branches, that a viewer ("participant" is a better word) may take through d material must already exist at some place on the disc. Entire prerecorded sectia of video may never be encountered by a given observen

Soon, the way we approach making films and videotapes will drástica! change. The notion of a "master" edil and "original" footage will disappe Editing will become the writing of a software program that will tell the compul how to arrange (i.e., shot order, cuts, dissolves, wipes, etc.) the information on *i* disc, playing it back in the specified sequence in real time or allowing the vie\i to intervene. Nothing needs to be physically "cut" or re-recorded at all. Playba speed, the cardinal 30 frames a second, will become intelligently variable and th malleable, becoming, as in electronic music practice, merely one fundamental £ quency among many which can be modulated, shifted up or down, supera posed, or interrupted according to the parameters of electronic wave theo Different sections can be assigned to play back at specific speeds or reversed; ai individual frames can be held still on the screen for predetermined duratioi Other sections can be repeated over and over. Different priorities rule how ai in what order one lays material down on the "master" (disc). New talents a skills are needed in making programs—this is not editing as we know it. It w Nikola Tesla, the original uncredited inventor of the radio, who called it "traj mission of intelligence." He saw something there that others didn't. After these years, video is finally getting "intelligence," the eye is being reattached the brain. As with everything else, however, we will find that the limitatia emerging lie more with the abilities and imaginations of the producers and use rather than in the tools themselves.

As in the figure/ground shifts described in Gestalt psychology, we are in I process oía shift away from the temporal, piece-by-piece approach *ofconstru ing* a program (symbolized by the camera and its monocular, narrow, tunnel-vision, single point of view), and towards a spatial, total-field approach of *cartn out* potentially múltiple programs (symbolized by the computer and its holia software models, data spaces, and infinite points of view). We are proceedi from models of the eye and ear to models of thought processes and concept structures in the brain. "Conceptual Art" will take on a new meaning.

"Will There Be [ondominíums ¡n Data Space?" 323

\s we take the first steps into data space, we discover that there have been many 3revious occupants. Artists have been there befo re. Giulio Camillo's Memory rheater (which he actually constructed in wood, calling it a "constructed body md soul") is one example. Dante's *Divine Gomedy* is another. Fascinating rela-[ionships between ancient and modern technologies become evident. A simple 2xample can be found in the Indian Tantric doctrine of the three traditional ex-pressions of the deity: the anthropomorphic, or visual, image; the yantra, or geo-metric "energy" diagram; and the mantra, or sonic representation through chanting and music. It is interesting to note that these are all considered to be equal—simply outward expressions of the same underlying thing. In form, this is not unlike the nature of electronic systems: the same electronic signal can be an image if fed into a video monitor, an energy diagram if fed into an oscilloscope, and a sequence of sounds if fed into an audio system.

Today, there are visual diagrams of data structures already being used to describe the patterns of information on the computer video disc. The most com-mon one is called "branching," a temí borrowed from computer science (figure 1). In this system, the viewer proceeds from top to bottom in time, and may ei-ther play the disc uninterrupted (arrow), or stop at predetermined branching points along the way and go off into related material at other áreas on the disc for further study (like a form of "visual footnoting"). Examples of this system go something like—in a program on the desert, the viewer can stop at a point where plants are mentioned, and branch off to more detailed material on the various flora of the valley floor, etc. Although it is clear how this can enhance our current educational system, freeing students from boring and incompetent teachers so they can proceed at their own pace through information which now contains movement, dynamic action, and sound in addition to written words, artists know that there must be more out there than this. Even though the technology is in-teractive, this is still the same oíd linear logic system in a new bottle.

As a start, we can propose new diagrams, such as the "matrix" structure (Figure 1). This would be a non-linear array of information. The viewer could enter at any point, move in any direction, at any speed, pop in and out at any place. All directions are equal. Viewing becomes exploring a territory, traveling through a data space. Of course, it would not be the obviously literal one like the Aspen pro-ject.[4] We are moving into *idea* space here, into the world of thoughts and images as they exist in the brain, not on some city planner's drawing board. With the in-tegration of images and video into the domain of computer logic, we are begin-ning the task of mapping the conceptual structures of our brain onto the technology. After the first TV camera with VTR gave us an eye connected to a

FIGURE 1. *Branching Structure, Matrix Structure, Schizo Structure.*

gross form of non-selective memoiy, we are now at the next evolutionary step — the área of intelligent perception and thought structures, albeit artificial.

Finally, we can envision other diagrams/models emerging as artists go deepeí into the psychological and neurological depths in search of expressions for var-lous thought processes and manifestations of consciousness. Eventually, certain forms of neurosis, so long the creative fuel of the tormented artist in the West, may be mapped into the computer disc. We may end up with the "schizo" oí "spaghetti" model, in which not only are all directions equal, but all are not equal (Figure 1). Everything is irrelevant and significant at the same time. Viewers may become lost in this Structure and never fmd their way out.

Worlds are waiting to be explored. It is to be hoped that artists will be given their share of access to experiment with this exciting new technology. I recently had a glimpse of some of the possibilities for art when I met a designer who had first encountered computers while working at a large French fashion design firrn in New York. There, the graphics artist worked at computer termináis. With a light-pen, he could draw various designs, working with functions of computei memory and data manipulation. Furthermore, his terminal was linked to a large databank of fabric designs and images from around the world and throughoul history. After completing a sketch, for example, he could cali up a seventeenth-century Japanese kimono design, look at it or superimpose it with his own idea. Then he could cali up a turn-of-the-century European dress pattern, combine that with his design or intégrate it with the kimono, all the while storing the various stages in memory. When all of this was completed and the final design cho-sen, he could then tie into other offices in Europe and the Orient right on the same screen. Designers could compare notes, get availability data on his fabric from the milis (i.e., where is the best silk, who has stock, what is the order time. etc.). All phases of his work could occur on the same screen as digital informadon. He could travel in space (Europe, the Far East), as well as in time (art history), all in an instant and available either as written text or visual images.

Despite the anti-technology altitudes which still persist (some, it should be added, for very good reasons), the present generation of artists, filmmakers, and video-makers currently in school, and their instructors, who continué to ignore computer and video technology, will in the near future find that they have bypassed *the* primary médium, not only of their own fields, but of the entire culture as well. It is imperative that creative artists have a hand in the developments currently underway. Computer video discs are being marketed as a great new tool in training and education. At this moment, there are creative people experimenting with the technology, ensuring that innovative and unique applications will emerge; but for now, many of the examples return to the boring domain of linear logic in the school classroom. The Aspen city map project is perhaps one of the more interesting examples of new program formáis. We are at the beginning, but even so, for the artisl, standard educational logic slruclures are jusl nol ihal interesting. Artists have been to different parís of the brain, and know quite well ihal ihings don'l always work like ihey lold you in school.

Il is of paramounl imporlance now, as we watch the same education system that brought us through school (and the same Communications syslem ihat gave us the wonderful world of commercial TV and AM radio) being mapped onto these new technologies, ihal we go back and lake a deeper look at some of the older systems described in these pages. Artisls nol shackled to ihe fad and fashion treadmill of ihe arl world, especially ihe arl world of ihe pasl few years, will begin lo see ihe new meaning ihal arl hislory is laking on. As I have begun lo oulline in ihis article, the relation between the image and architecture (as in Renaissance arl), the strucluralism of sacred arl (Orienlal, Early Chrislian, and Tribal art, with their mándalas, diagrams, icons, and olher symbolic represenlations, including song, dance, poetry), and artificial memory systems (the first recording technologies from the time of the Greeks through the Middle Ages), are all áreas thal require furlher invesligalion.

As we continué lo do our dance with lechnology, some of us more willingly than others, the importance of turning back lowards ourselves, ihe prime mover of this lechnology, grows grealer than the importance of any LSI circuit. The sacred art of the pasl has unified form, function, and aesthetics around this single ultímate aim. Today, developmenl of self must precede development of the technology or we will go nowhere—there *will* be condominiums in data space (it has already begun with cable TV). Applications of tools are only reílections of the users—chopsticks may be a simple eating utensil or a weapon, depending on who uses them.

Late one night while driving down a narrow mountain highway, I came across a large porcupine crossing the road up ahead. Fortunately, I spotted him in time to bring the car to a stop a short distance from where he was standing. I watched him in the bright headlights, standing motionless, petrified at this "close en-counter of the third kind." Then, after a few silent moments, he started to do a strange thing. Staying in his place, he began to move around in a circle, emitting a raspy hissing sound, with the quills rising up offhis body. He didn't run away. I realized that this dance was actually a move of self-defence. I cut the car headlights to normal beams, but he still continued to move around, even more furi-ously, casting weird shadows on the trees behind. Finally, to avoid giving him a heart attack, and to get home, I cut the lights completely and turned offthe en-gine. I watched him in the dim moonlight as he stopped his dance and moved off the road. Later, while driving off, I realized that he was probably walking proudly away, gloating over how he really gave it to that big blinding noisy thing that rushed toward him out of the night. I'm sure he was filled with confidence, so pleased with himself that he had won, his porcupine world-view grossly inflated as he headed home in the darkness.

Lynn i-iersnman

'The Fantasy Beyond Control" (1990)

32

Lynn Hershman,* Deep Contad. © *Lynn

Hershman. Courtesy ofLynn Hershman.

"Tradítional narratives are be'mg restructured. As a resalí, people feel a greater need to personally particípate ¡n the discovery of valúes that affect and order their Uves, to díssolve the divisíón that separates them from control, freedom; replacing longing, nostalgia and emptiness with a sense ofidentity, purpose and hope."

« Media artist Lynn Hershman divides her work into two categories: B.C. (Before Computers) and A.D. (After Digital). The line of demarcation occurreí around 1980 as ¡nteractive technologies, including personal computers and laserdisc players, became commerdally available. In her early performance work!

and site-specific installations (B.C.), Hershman had begun exploring themes thal focused on issues of identity, alienation, and the blurring between reality and fietion.The introduction of computers into her work (A.D.) was a natural consfr quence of her pursuit of these themes. The confluence of these interests, th« theatrical nature of her ideas, and the types of explorations suggested by emerging interactive technologies led her into groundbreaking creative terrain. She wa< one of the few artists to grasp the expressive possibilities of electronic media anc to transíate its potential into major interactive artworks for the médium.

In this essay, Hershman discusses two key works from the early 1980s th ¡Ilústrate how she adopted electronic media to explore new narrative strategie: that required and exploited viewer ¡nteraction.The first of these works was *Lorm* (1982), the seminal art videodisc: a labyrinthine journey through the mental landscape of an agoraphobic middle-aged woman.Trapped in the seclusion of hei tiny apartment, the fictional character Lorna is obsessed with media, televisión, and the bizarre objects of her room.The viewer navigates through the branchin? structure of the videodisc to make decisions that ultimately determine the fate of Lorna's sordid existence. As Hershman points out in this essay, Lorna's pas-sive relation to media and ufe is juxtaposed with the viewer's newfound agencj to select and reassemble the narrative's branching themes, stories, interpreta-tions, and conclusions.

Hershman describes her new media artworks as exploring "the interaction and intimacy of people despite technological separations." In Deep Contad (1984-1989), the other work discussed ¡n this essay, Hershman uses a touch-screen interface to suggest that the viewer can reach through the work's glas^ surface, the computer's "fourth wall."The user's interactions are incorporateí into the unfolding narrative to confront issues of voyeurism, eroticism, and nar-cissism. In Deep *Contad,* "touching" the protagonist Marión becomes an erotic ges-ture, the extensión of a phantom limb into the illusionary world of virtual storyspace. As Hershman puts it, this type of interactivity constitutes a trans-gression of the screen, and transports the viewer into virtual reality. Interactior with virtual characters (including the viewer's own ¡mage, which is projected inte the virtual space), encourages the viewer to break free from the traditional au-dience role of passive recipient by navigating through the work's many branching narrative paths. »

> A fascinating first. *Loma* is a stream of consciousness collage that requires not only an Interactive left brain, to deduce and make logical cholees, but also an in-teracüve right brain, to feel what the character's feeling and to understand her life. Whatever *Lorna's* fate, Lynn Hershman has scored one for the history books."
>
> —*Video Magazine*

Despite some theories to the contrary, it is presumed that making art is active and /iewing art is passive. Radical developments in communication technology, such is the marriage of image, sound, text, computers and interactivity, have chal-lenged this assumption. The participants *oí Loma* have reported that they had the impression of being empowered because they could manipúlate Lorna's life. The decisión process was placed in their hands, literally. The media bath of transmitted, pre-structured and edited information that surrounds, and some say aliénales, people is washed away, hosed down by viewer input. Altering the basis for the information exchange is subversive and encourages participation cre-ating a different audience dynamic.

Interactive systems require viewers to react. Choices must be made. As technology expands, there will be more permutations available, not only between the viewer and the system, but between elements within the system itself. Computer systems will eventually reflect the personality of their users. However, there is a space between the system and player in which a link, a fusión or transplant occurs. Truth and fiction blur. According to Sigmund Freud, reality may be lim-ited to percepúons that can be verified through words or visual codes. Therefore, perceptions are the drive to action that infiuence, if not control, real events. Per-ceptions become the key to reality.

Perhaps it was nostalgia that led me to search for an Interactive video fantasy. a craving for control, a longing for real-time activities, a drive toward direct action. This chronic condition is reputedly a side effect, or for video artists an oc-cupational hazard, that results from watching too much televisión. Televisión is a médium that is by its nature fragmentary, incomplete, distanced and unsatisfy-ing, similar to platonic sex. A precondition of a video dialogue is that it does not talk back. Rather, it exists as a moving stasis, a one-sided discourse, a trick mir-ror that absorbs rather than reílects.

Loma was developed as a research and development guide, but it is gener-ally inaccessible as it was pressed in a limited edition of 20, of which only 14 now exist. *Loma* is only occasionally installed in galleries or museums. Creating a truly interactive work demands that it exist on a mass scale, available and acces-sible to many people.

My path to interactive works began not with video, but with performano when, in 1971,1 created an alternative identity named Robería Breitmore. He decisions were random, only very remotely controlled. Roberla's manipulaled re alily became a model for a prívale syslem of inleractive performances. Inslead o being kept on a disc or hardware, her records were stored as photographs aru texis that could be viewed wilhoul predetermined sequences. This allowed view ers to become voyeurs into Roberla's hislory. Their inlerpretations shifled, de pending on ihe perspeclive and order of ihe sequences.

Two years afler Roberta's transformation, *Lorna,* the first interactive ar videodisc, was completed. Unlike Robería, who has many advenlures direclly ii the environment, Lorna, a middle-aged, fearful agoraphobic, never leaves ha tiny aparlmenl. The premise was ihal ihe more she slays home and walches lele visión, ihe more fearful she becomes, primarily because she absorbs the fright ening messages of advertising and news broadcasls. Because she never leava home, ihe objecls in her room lake on a magnificent proportion.

Every objecl in Lorna's room is numbered and becomes a chapler in her lifi that opens into branching sequences. The viewer, or participanl, accesses infor malion aboul her pasl, future and personal conflicts via these objects. Many im ages on ihe screen are of ihe remote control device Lorna uses to changí televisión channels. Because ihe viewer uses a nearly identical unit lo direcl th< disc aclion, a melaphoric link or poinl of idenlificalion is eslablished belween ih< viewer and Lorna. The viewer actívales ihe live action and makes surrogate decisions for Lorna. Decisions are designed into a branching path. Although therc are only 17 minutes of moving image on ihe disc, ihe 36 chaplers can be se-quenced difíerently and played over a period of time lasling several days. There are ihree sepárale endings lo ihe disc, ihough ihe plol has mulliple varialions ihal include being caughl in repeating dream sequences, or using múltiple sound-Iracks, and can be seen backward, forward, at increased or decreased speeds, and from several points of view.

There is no hierarchy in ihe ordering of decisions. Il should be noled ihal thia idea is not new. It was explored by such artists as Stephen Mallarme, John Cage and Marcel Duchamp, particularly through his music. These artists pioneered ideas about random advenlures and chance operalions 50 years before ihe in-venlion of ihe lechnology that would have allowed them to exploit iheir concepta more fully.

Lorna's passivity, caused by being controlled by the media, is a counterpoinl to the direct aclion of the participante. As the branching palh is deconstrucled, players become aware of ihe sublle yel powerful effecls of fear caused by ihe

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nedia, and become more empowered, more active. By acting on Lorna's behalf ive travel through their own internal labyrinth to our innermost transgressions.

As Interactive technology is increasingly visible in many áreas of society the political impact is spectacular. Traditional narratives are being restructured. As a result, people feel a greater need to personally participate in the discovery of valúes that affect and order their lives, to dissolve the división that sepárales them from control, freedom; replacing longing, nostalgia and emptiness with a sense of identity, purpose and hope.

The second piece, *Deep Contad,* refers to the players' ability to travel the 57 different segments into the deepest part of the disc, determining, through their own intuition, the route to the centre, while simultaneously trying to find and to feel the deepest, most essential parts of themselves. Viewers choreograph their own encounters in the vista of voyeurism that is incorporated into *Deep Contact.*

This piece developed into a collaboration between many people. John Di Ste-fano had the difficult task of composing music that would work in modulated segments, as well as backward, forward or in slow-motion. Jiri Vsneska assisted immeasurably with the shooting and scanning of photographic images, and Marión Grabinsky, the leather-clad protagonist, gave the piece the erotic appeal so necessary for sexual transgressions. Toyoji Tomita played the Zen Master and Demon with equal charm, while the crew of camera operators, editors and pro-duction managers added tremendously to the success and joy of making this piece.

This touch-sensitive interactive videodisc installation compares intimacy with reproductive technology, and allows viewers to have adventures that change their sex, age and personality. Participants are invited to follow their instincts as they are instructed to actually touch their "guide" Marión on any part of her body. Adventures develop depending upon which body part is touched.

The sequence begins when Marión knocks on the projected video screen ask-ing to be touched. She keeps asking until parts of her body, scanned and pro-grammed to roíate onto ihe Microlouch screen, aclually are louched. For instance, if you touch her head, you are given a choice of TV channels, some giv-ing short, but humorous, analytic accounts of "reproductive technologies" and their effect on women's bodies while others show how women see themselves. The protagonist also talks about "extensions" into the screen that are similar to "phantom limbs," so that the screen becomes an extensión of the participant's hand. Touching the screen encourages the sprouting of phantom limbs, virtual connections between viewer and image.

If Marion's torso is touched, the video image on the disc goes to a bar where the viewer can select one of three characters, Marión, a Demon or a Voyeur, to follow through interactive fiction that has a video component. If viewers touch Mar-ion's legs, they enter a garden sequence in which they can follow Marión, a Zen Master, an Unknown Path or a Demon. Selections are made via images that have been photographically scanned onto the touchscreen. In the garden, for example, the image on the touchscreen is a hand that jumps forward depending upon selections, and that allows the viewer to follow the lines on the hands to differ-ent routes. The participant usually follows a character or a segment to a fork in the road. At this point, the disc automatically stops, requiring a selection to go left, to go to the right, to return to the first segment of the disc, or to repeat the segment just seen.

At certain instances viewers can see, cióse up, what they have just passed. For example, Marión runs past a bush that, examined closely, reveáis a spider weav-ing a web. This allows new perceptions of the same scene, depending upon the speed at which it is seen. In some instances words are flashed on the screen for just three frames, forcing the viewer to go back slowly to see what was written. At other points lines are spoken backward, forcing the disc to be played in reverse. Whilst the Demon and Zen Master are played by the same actor, indicating dif-ferent aspects of our personalities, suggesting that the same event can appear frightening or enlightening, depending upon its context.

A surveillance camera was programmed via a Fairlight to be switched "on" when a cameraman's shadow is seen. The viewer's image instantaneously appears on the screen, displacing and replacing the image. This suggests "transgressing the screen" being transported into "virtual reality."

<oy ascott

Is There Love in the Telematic Embrace?"

33

(1990)

Roy Ascott, **Aspects of Gaia: Digital Pathways Across the Whole Earth.** ***Courtesy o/Roy Ascott.***

'Telematics... involves the technology of interactions among human beíngs and between the human m'md and artificial systems of ¡ntelligence and perception. The individual user of networks ¡s always potentially involved ¡n a global net, and the world ¡s always potentially in a state of interaction with the individual."

« In the 1980s Roy Ascott presented a body of art based on telecommunications technologies, or, as he called ¡t, "telematic art/' at leading-edge Europeai exhibitions of art and technology. These included a pivotal show at the 198Í Venice Biennale, "Art,Technology and Computer Science," and the 1989 debu' of his *Aspeas of Gala: Digital Pathways across the Whole Earth ai* Ars Electrónica, ir Austria. For the latter project, Ascott invited artists, musicians, and scientist from around the world to contribute digital representations of the earth (GaiaJ by way of the global telecommunications network. Ascott's exploration of telem-atics prefigured the explosión of Internet art in the mid-1990s, shortly after th< emergence of the World Wide Web.

With the title of this essay, Ascott begs the question of whether artistic worl that incorporates telecommunications technologies ¡s truly engaging and of quality. He observes how the global network is bringing about a "telematic culture' ¡n which participants are "always potentially in a state of interaction/'This dynamic Communications environment, he notes, will lead to new opportunities foi artistic expression. One consequence will be the emergence of the "integratec data work," which he defines as a digital artwork that derives ¡ts expressivenes? from a "many-to-many" type of interaction. This collective interaction *betweet* viewers shares much with the Happenings of an earlier era.

Ascott concludes that telematic art encourages the artist to assume the rol< of facilitator, rather than be the solé arbiter of the artwork's creation.This empowers the participant and enhances the viewer's capacity for creative thoughl and action. In telematic art, he explains, the dynamic action between participant! ¡s determined by the work's interface.This approach ¡s quite unlike the traditiona! view of the *objet d'art,* which concentrates on the static surface of the painting oí sculpture as executed by the inspired *artiste.* As Ascott explains, "at the interface to telematic systems, content ¡s created rather than received." By determining thí interface, the artist shapes the participant's particular experience by using networked interaction to créate a form of participatory narrative—a radical op< portunity for personal expression unlike any established artistic genre. »

1 he past decade has seen the two powerful technologies of computing and telecommunications converge into one field of operadons that has drawn into its embrace other electronic media, including video, sound synthesis, remote sens-ing, and a variety of cybernetic systems. These phenomena are exerting enor-mous influence upon society and on individual behavior; they seem increasingly

to be calling into question ihe very nalure of whal il is to be human, to be creative, to think and to perceive, and indeed our relationship to each other and lo the planel as a whole. The "telematic culture" thal accompanies ihe new develop-menls consisls of a sel of behaviors, ideas, media, valúes, and objeclives ihal are significanlly unlike those thal have shaped society since the Enlightenmenl. New cullural and scienlific metaphors and paradigms are being generated, new mod-els and representations of reality are being invented, new expressive means are being manufactured.

Telemalics is a lerm used lo desígnale compuler-mediated Communications networking involving telephone, cable, and satellite links belween geographically dispersed individuáis and inslilulions that are interfaced to data-processing systems, remole sensing devices, and capacious data-slorage banks.[1] Il involves ihe lechnology of interaction among human beings and between the human mind and artificial systems of intelligence and perception. The individual user of net-works is always polenlially involved in a global nel, and ihe world is always po-tentially in a state of interaction with ihe individual. Thus, across the vasl spread af telematic networks worldwide, ihe quantity of data processed and ihe densily }f informalion exchanged is incalculable. The ubiquilous efíicacy of ihe telem-ilic médium is nol in doubl, bul the question in human lerms, from ihe poinl of áew of culture and creativity, is: Whal is the contení?

This question, which seems to be at the heart of many critiques of art nvolving computers and lelecommunications, suggesls deep-sealed fears of he machine coming lo domínale ihe human will and of a technological formal-sm erasing human contení and valúes. Aparl from all ihe parliculars of personal istories, of dreams, desires, and anxieties that inform the contení of art's rich spertoire, the question, in essence, is asking: Is there love in the telematic em-race?

In ihe attempl to extricale human contení from technological form, the ques- on is made more complicated by our increasing lendency as artists to bring to- ;lher imaging, sound, and text systems into interactive environments ihal exploil ate-of-lhe-arl hypermedia and that engage the full sensorium, albeit by digital eans. Oul of this technological complexily, we can sense ihe emergence of a syn- esis of ihe arls. The question of contení musí iherefore be addressed to what ight be called the *Gesamtdatenwerk*—the integraled dala work—and lo its ca- icity to engage the intellecl, emolions, and sensibilily of ihe observen[2] Here, iwever, more problems arise, since ihe observer in an interactive telematic sys- n is by definition a participator. In a telematic art, meaning is not something :ated by the artist, dislribuled ihrough the network, and *received* by ihe ob- •ver. Meaning is ihe producl of interaction between the observer and the sys- tem, the contení of which is in a state of flux, of endless change and transión tion. In this condition of uncertainty and inslabilily, not simply because of I crisscrossing interactions of users of the network but because contení is e bodied in data ihat is itself immaterial, it is puré electronic *difference,* until it I been reconstituted at the interface as image, lexl, or sound. The sensory *out*\ may be differenlialed furlher as exisling on screen, as articulated slruclure malerial, as architecture, as environmenl, or in virlual space.

Such a view is in line wilh a more general approach lo art as residing ii cultural Communications system rather than in the arl objecl as a íixed seman configuraron—a system in which the viewer aclively negoliates for meaning.[3] this sense, lelemalic networking makes explicit in ils lechnology and prolocl what is implicit in all aesthetic experience where that experience is seen as bei as much crealive in ihe acl of the viewer's perception as it is in the act of t arlist's production.[4] Classical Communications iheory holds, however, **ti** communication is a one-way dispatch, from sender to receiver, in which oí contingent "noise" in the channel can modify the message (often íiirther confus as the meaning) initiated at the source of transmission.[5] This is the model that h the artist as sender and iherefore originalor of meaning, ihe artist as creator ai owner of images and ideas, the artist as controller of contexl and contení. It ii model that requires, for its completion, the viewer as, at besl, a skilled decod or interpreter of the artist's "meaning" or, at worst, simply a passive receplacle such meaning. It gives rise lo ihe industry of crilicism and exegesis in whi< those who "understand" ihis or thal work of arl explain il lo ihose who are U stupid or uneducated to receive its meaning unaided. In this scenarío, the artwa and its maker are viewed in the same way as ihe world and its creator. The beau and truth of both art and the world are "out there" in the world and in ti work of art. They are as fixed and immulable as the material universe appea to be. The canon of determinism decrees prefigured harmony and compos tion, regulaled form and continuity of expression, with unily and clarily assurc by a cultural consensus and a linguistic uniformity shared by arlisl and publ alike.

The problem of conlenl and meaning within a lelematic culture gives adde poignancy to ihe rubric "Issues of Conlenl" under which this present wriling o compulers and art is developed: "issue" is open to a plurality of meanings, no oí of which is salisfaclory. The melaphor of a semantic sea endlessly ebbíng an flowing, of meaning constantly in flux, of all words, utlerances, geslures, and in ages in a stale of undecidability, tossed to and fro into new collusions and coi junctions wilhin a field of human interaclion and negolialion, is found as muc in new science—in quanlum physics, second-order cybernelics,[6] or chaology,[7] fe

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xample—as in art employing telematic concepts or the new literary criticism that las absorbed philosophy and social theory into its practice. This sunrise of un-ertainty, of a joyous dance of meaning between layers of genre and metaphoric ystems, this unfolding tissue woven of a multiplicity of visual codes and cultural maginations, was also the initial promise of the postmodern project before it dis-;ppeared into the domain of social theory, leaving only its frail corpus of pes-imism and despair.

In the case of the physicists, the radical shift in metaphors about the world md our participation in its creation and redescription mean that science's picure window onto reality has been shattered by the very process of trying to mea-•ure it. John Wheeler uses this analogy succinctly:

> Nothing is more importan! about the quantum principie than this, that it destroys the concept of the world as "sitting out there," with the observer safely separated from it by a 20-centimeter slab of píate glass. Even to observe so minuscule an ob-ject as an electrón, he must shatter the glass. He must reach in. He must install his chosen measuring equipment. It is up to him whether he shall measure po-sition or momentum … the measurement changes the state of the electrón. The universe will never afterwards be the same. To describe what has happened one has to cross out that oíd word "observer" and put in its place "participator." In some strange sense the universe is a participatory universe.[8]

In the context of telematic systems and the issue of contení and meaning, the •arallel shift in art of the status of "observer" to that of "participator" is demon-trated clearly if in accounts of the quantum principie we substitute "data" for quanta." Indeed, fmding such analogies between art and physics is more than ist a pleasant game; the web of connections between new models of theory and ractice in the arts and the sciences, over a wide domain, is so pervasive as to sug-est a paradigm shift in our world view, a redescription of reality and a recon-¡xtualization of ourselves. We begin to understand that chance and change, laos and indeterminacy, transcendence and transformation, the immaterial and le numinous, are terms at the center of our self-understanding and our new vi-ons of reality. How, then, could there be a contení—sets of meanings—con-ined wilhin telematic art when every aspect of nelworking in dalaspace is in a ale of Iransformalion and of becoming? The very lechnology of compuler lecommunicalions extends the gaze, transcends the body, amplifies the mind to unpredictable configurations of thought and creativily....

I the recent history of Weslern arl, il was Marcel Duchamp who firsl look ihe elaphor of ihe glass, of ihe window onlo ihe world, and turned it back on itself to reveal what is invisible. We see in the work known as *The Bride Stripped Barr by Her Bachelors, Even,* or *The Large Glass,* a field of vitreous reality in which en-ergy and emotion are generated from the tensión and interaction of male and fe-male, natural and artificial, human and machine.[9] Its subject is attraction in Charles Fourier's sense,[10] or, we might even say, love. *The Large Glass,* in its transparent essence, always includes both its environment and the reflection of the observen Love is contained in this total embrace; all that escapes is reason and certainty. By participating in the embrace, the viewer comes to be a progenitor of the semantic issue. The glass as "ground" has a function and status anticipatíng that of the computer monitor as a screen of operations—of transformations— and as the site of interaction and negotiation for meaning. But it is not only through the *Glass* that we can see Duchamp as prophetic of the telematic mode. The very metaphor of networking interaction in a field of uncertainty, in which the observer is creator and meaning is unstable, is implicit in all his work. Eqt prophetic in the *Glass* is the horizontal bar that joins the upper and lower] of the work and serves as a metaphor for the all-around viewing, the inclusive.; embracing scope of its visión. This stands in opposition to the vertical, head-t toe viewing of Renaissance space, embodied in the Western pictorial tradition where the metaphor of verticality is employed insistently in its monuments ; architecture —emblems often as not of aggression, competition, and dominanc always of a tunnel visión. The horizontal, on the other hand, is a metaphor for t bird's-eye view, the all-over, all-embracing, holistic systems view of structures. relationships, and events—viewing that can include the ironic, the fuzzy, and dx ambiguous. This is precisely the condition of perception and insight to which telematic networking aspires....

As Communications networks increase, we will eventually reach a point wherc the billions of information exchanges, shuttling through the networks at any om time, can créate coherence in the global brain, similar to those found in th< human brain.[11]

This suggests equally the need for a redescription of human consciousnes as it emerges from the developing symbiosis of the human mind and the artificia thought of parallel distributed processing (PDP).[12]

If one of the great rituals of emergence into a new world—that of the Ameri can Indian Hopi—is centered around the sacred sipapu that connects to the Unn derworld of power and transformation, so our emergence into the new world o telematic culture similarly calis for celebration at the interface to those PDP sv?-tems that can link us with superconnectivity, mind to mind, into a new planet community. And just as the Hopi seek to exploit the full measure of their

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pressive means byjoining image, music, chant, and dance into a holistic unity, so we too now seek a synthesis of digital modes—image, sound, text, and cybernetic structure—by which to recontextualize our own world, that numinous whole of all our sepárate realities.

The emerging new order of art is that of interactivity, of "dispersed authorship";[13] the canon is one of contingency and uncertainty. Telematic art encompasses a wide array of media: hypermedia, videotex, telefacsimile, interactive video, computer animation and simulation, teleconferencing, text exchange, image transfer, sound synthesis, telemetry and remote sensing, virtual space, cybernetic structures, and intelligent architecture. These are simply broad categories of technologies and methodologies that are constantly evolving— bifurcating, joining, hybridizing—at an accelerated rate.

At the same time, the status of the art object changes. The culturally dominant objet d'art as the solé focus (the uncommon carrier of uncommon contení) is replaced by the interface. Instead of the artwork as a window onto a com-posed, resolved, and ordered reality, we have at the interface a doorway to un-decidabiliry, a dataspace of semantic and material potentiality. The focus of the aesthetic shifts from the observed object to the participating subject, from the analysis of observed systems to the (second-order) cybernetics of observing sys-tems: the canon of the immaterial and participatory. Thus, at the interface to telematic systems, contení is created rather than received. By the same token, contení is disposed of at the inlerface by reinserting it, transformed by the process af inleraclion, back inlo ihe network for storage, distribution, and eventual trans-formation at the interface of other users, at other access nodes across the planet. A telematic network is more than the sum of its parts, more than a computer Communications web. The new order of perception it constitutes can be called 'global visión," since its distributed sensorium and distributed intelligence— ictworked across the whole planet as well as reaching remotely into galactic pace and deep into quantum levéis of matter—together provide for a holistic, in-egrative viewing of structures, systems, and events that is global in its scope. This rtificial extensión of human intelligence and perception, which the neural nets f PDP and sophisticated remote-sensing systems provide,[14] not only amplifies uman perception but is in the process of changing it. The transformation is en-rely consistent with the overarching ambition of both art and science through-ut this century: to make the invisible visible. Even now, it must be recognized Iat our human cognitive processes (whether involving linear or associative lought, imaging, remembering, computing, or hypothesizing) are rarely carried *it* without the computer being involved.[15] A great proportion of the time that we are involved in communicating, learning, or being entertained entails our i teraction with telecommunications systems.[16] Similarly, with feeling and sensii artificial, intelligent sensors of considerable subtlety are becoming integral human interaction with the environment and to the monitoring of both inten and external ecologies. Human perception, understood as the product of act negotiation rather than passive reception, thus requires, within this evolvi symbiosis of human/machine, telematic links of considerable complexity 1 tween the very diverse nodes of the worldwide artificial reticular sensorium.

Telematic culture means, in short, that we do not think, see, or feel in isa tion. Creativity is shared, authorship is distributed, but not in a way that den the individual her authenticity or power of self-creation, as rather crude mod of collectivity might have done in the past. On the contrary, telematic culd amplifies the individual's capacity for creative thought and action, for more vr and intense experience, for more informed perception, by enabling her to p ticipate in the production of global visión through networked interaction w other minds, other sensibilities, other sensing and thinking systems across i planet—thought circulating in the médium of data through a multiplicity of« ferent cultural, geographical, social, and personal layers. Networking suppc endless redescription and recontextualization such that no language or vis code is final and no reality is ultimate. In the telematic culture, pluralism and i ativism shape the configurations of ideas—of image, music, and text—that i culate in the system.

It is the computer that is at the heart of this circulation system, and, like heart, it works best when least noticed—that is to say, when it becomes invisil At present, the computer as a physical, material presence is too much with u¡ dominates our inventory of tools, instruments, appliances, and apparatus as ultimate machine. In our artistic and educational environments it is all too soli there, a computational block to poetry and imagination. It is not transpan ñor is it yet fully understood as puré system, a universal transformative mat The computer is not primarily a thing, an object, but a set of behaviors, a systi actually a system of systems. Data constitute its lingua franca. It is the agent of datafield, the constructor of dataspace. Where it is seen simply as a screen j senting the pages of an illuminated book, or as an internally lit painting, it i no artistic valué. Where its considerable speed of processing is used simpl] simúlate filmic or photographic representations, it becomes the agent of pas! voyeurism. Where access to its transformative power is constrained by a tj writer keyboard, the user is forced into the posture of a clerk. The electro palette, the light pen, and even the mouse bind us to past practices. The po"

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of the computer's presence, particularly the power of the interface to shape lan-^uage and thought, canriot be overestimated. It may not be an exaggeration to say that the "content" of a telematic art will depend in large measure on the nature DÍ the interface; that is, the kind of configurations and assemblies of image, sound, and text, the kind of restructuring and articulation of environment that telematic interactivity might yield, will be determined by the freedoms and fluidity avail-ible at the interface.

The essence of the interface is its potential flexibility; it can accept and deiver images both fixed and in movement, sounds constructed, synthesized, or sampled, texts written and spoken. It can be heat sensitive, body responsive, en-/ironmentally aware. It can respond to the tapping of the feet, the dancer's irabesque, the direction of a viewer's gaze. It not only articúlales a physical en-/ironment with movement, sound, or light; it is an environment, an arena of data-space in which a distributed art of the human/computer symbiosis can be acted jut, the issue of its cybernetic content. Each individual computer interface is an ispect of a telematic unity such that to be in or at any one interface is to be in the virtual presence of all the other interfaces throughout the network of which it is *i* part. This might be defined as the "holomatic" principie in networking. It is so Decause all the data flowing through any access node of the network are equally md at the same time held in the memory of that network: they can be accessed, ;hrough cable or satellite links, from any part of the planet at any time of day or light, by users of the network (who, in order to communicate with each other, lo not need to be in the same place at the same time).

This holomatic principie was well demonstrated during the Venice Biennale >f 1986, when the *Planetary Network* project had the effect of pulling the exhi>ition from its rather élite, centralized, and exclusive domain in Venice and tretching it out over the face of the globe;[1]' the flow of creative data generated iy the interaction of artists networking all over the world was accessible everydiere. Set within the interactive environment "Laboratory Ubiqua," a wide range f telematic media was involved, including electronic mail, videotex, digitalnage exchange, slow-scan TV, and computer conferencing. Interactive ideodiscs, remote sensing systems, and cybernetic structures were also inluded....

A more elabórate and complex multimedia interface was created for the pro-:ct *Aspects of Gaia: Digital Pathways across the Whole Earth* as part of the Ars lectronica Festival of Art and Technology in Linz, Austria, in 1989.[18] The trans-lission of digital image and sound by file transfer and the computer storage of lefacsimile material via modem, by this time economically feasible, invited the creation of a more dramatic and engaging environment for public particip Invitations to particípate in the project were emailed, faxed, or airmai "artists, scientists, poets, shamen [sic], musicians, architects, visionaries riginal artists of Australia, native artists of the Americas." The subject of th ject was the many aspects of the earth, Gaia, seen from a multiplicity of spi scientific, cultural, and mythological perspectives. An energizing stream o grated digital images, texts, and sounds (a *Gesamtdatenwerk)* would thei stitute a kind of invisible cloak, a digital noosphere that might contribute harmonization of the planet. In accessing the meridians at various noda ticipants became involved in a form of global acupuncture, their intera endlessly transforming and reconstituting the worldwide flow of creative da

To the objection that such a global visión of an emerging planetary art critically euphoric, or that the prospectus of a telematic culture with its *Gt datenwerk* of hypermediated virtual realities is too grandiose, we should p« remind ourselves of the essentially political, economic, and social sensibili those who laid the conceptual foundations of the field of interactive sys This cultural prospectus implies a telematic politic, embodying the featu feedback, self-determination, interaction, and collaborative creativity not i the "science of government" for which, over 150 years ago, Andre Marie Ai coined the term "cybernetics"—a term reinvigorated and humanized by bert Wiener in this century.[19] Contrary to the rather rigid determinism an« itivism that have shaped society since the Enlightenment, however, these fe will have to accommodate notions of uncertainty, chaos, autopoiesis. c» gency, and the second-order cybernetics or fuzzy-systems view of a wa which the observer and observed, creator and viewer, are inextricably Uní the process of making reality—all our many sepárate realities interacting. . ing, re-forming, and resonating within the telematic-noosphere of the plai

Within these sepárate realities, the status of the "real" in the phenomen of the artwork also changes. Virtual space, virtual image, virtual reality—thí categories of experience that can be shared through telematic networks. allí for movement through "cyberspace" and engagement with the virtual pre of others who are in their corporeal materiality at a distance, physically in¡ sible or otherwise remote.[20] The adoption of a headset, DataGlove, or othe wear can make the personal connection to cyberspace—socialization in h reality—wherein interaction with others will undoubtedly be experieiu "real," and the feelings and perceptions so generated will also be "reaLI passage from real to virtual will probably be seamless,just as social behavi rived from human-computer symbiosis is flowing unnoticed into OUI sciousness.

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But the very ease of transition from "reality" to "virtuality" will cause confusión in culture, in valúes, and in matters of personal identity. It will be the role of the artist, in collaboration with scientists, to establish not only new creative praxes but also new valué systems, new ordinances of human interaction and social communicability. The issue of conteni in the planetary art of this emerging telematic culture is therefore the issue of valúes, expressed as transient hypothe-ses rather than finalities, tested within the immaterial, virtual, hyperrealities of dataspace. Integrity of the work will not be judged by the oíd aesthetics; no an-:ecedent criteria can be applied to network creativity since there is no previous :anon to accommodate it. The telematic process, like the technology that em-Dodies it, is the product of a profound human desire for transcendence: to be out)f body, out of mind, beyond language. Virtual space and dataspace constitute the lomain, previously provided by myth and religión, where imagination, desire, md will can reengage the forces of space, time, and matter in ihe battle for a new eality. The digital matrix that brings all new electronic and optical media into its slematic embrace—being a connectionist model of hypermedia—calis for a "conective criticism." The personal computer yields to the interpersonal computen erial data processing becomes parallel dístributed processing. Networks link icmory bank to memory bank, intelligence to intelligence. Digital image and igital sound find their common groundjust as a synthesis ofmodes—visual, lacle, textual, acoustic, environmental—can be expected to "hypermediate" the jtworked sensibilities of a constellation of global cultures. The digital camera— ithering still and moving images from remote sensors deep in space, or directed ′ human or artificial intelligence on earth, seeking out what is unseen, imaging *lat* is invisible—meets at a point between our own eyes and the reticular retina worldwide networks, stretching perception laterally away from the tunnel vi->n, from the Cartesian sight lines of the oíd deterministic era. Our sensory ex-rience becomes extrasensory, as our visión is enhanced by the extrasensory vices of telematic perception. The computer deals invisibly with the invisible. Drocesses those connections, collusions, systems, forces and fields, transfor-tions and transferences, chaotic assemblies, and higher orders of organization t lie outside our visión, outside the gross level of material perception afforded our natural senses. Totally invisible to our everyday unaided perception, for mple, is the underlying fluidity of matter, the indeterminate dance of electrons, "snap, crackle, and pop" of quanta, the tunneling and transpositions, nonlo-and superluminal, that the new physics presents. It is these patterns of events, >e new exhilarating metaphors of existence—nonlinear, uncertain, layered, discontinuous—that the computer can redescribe. With the computer, and brought together in the telematic embrace, we can hope to glimpse the unsee to grasp the ineñable chaos of becoming, the secret order of disorder. And a come to see more, we shall see the computer less and less. It will become in ble in its immanence, but its presence will be palpable to the artist engaged te atically in the world process of autopoiesis, planetary self-creation.

The technology of computerized media and telematic systems is no long be viewed simply as a set of rather complicated tools extending the ran¡ painting and sculpture, performed music, or published literature. It can no seen to support a whole new field of creative endeavor that is as radically u each of those established artistic genres as they are unlike each other. A nei hiele of consciousness, of creativity and expression, has enterad our repertd being. While it is concerned with both technology and poetry, the virtual an immaterial as well as the palpable and concrete, the telematic may be cal rized as neither art ñor science, while being allied in many ways to the discoi of both. The further development of this field will clearly mean an interde dence of artistic, scientific, and technological competencies and aspirations urgently, on the formulation of a transdisciplinary education.

So, to link the ancient image-making process of Navajo sand painting t digital imaging of modern supercomputers through common silicon, W serves them both as pigment and processor chip, is more than ironic whimsy, holistic ambition of Native American culture is paralleled by the holistic p* tiality of telematic art. More than a technological expedient for the interch of information, networking provides the very infrastructure for spiritual i change that could lead to the harmonization and creative development o whole planet. With this prospectus, however na'ively optimistic and traru dental it may appear in our current fin-de-siécle gloom, the metaphor of lo the telematic embrace may not be entirely misplaced.

Kit balloway and Sherne Rabmowitz

"Welcome to 'Electronic Cafe International': A Nice Place For Hot CoFFee, Ieed Tea, £7 Virtual Space" (1992)

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Dancers Keija, Mitsuko, and Soto 3000 miles apart! **Satellite Arts Project: A Space with No Geographical Boundaries. © 7977** ***Galloway/Rabinowitz.***

" We *fírst explored composíte-image space because we wanted to créate a performance place with no geographical boundaríes, in whích we cou/d collaborate with other artists."*

« In 1984, Kit Galloway and Sherrie Rabinowitz debuted the prototype of Electronic Cafe by linking five cafes in various communities in Los Angeles to Museum of Contemporary Art for the Olympic Arts Festival. Five years later; t opened the Electronic Cafe International in Santa Monica, California, wlj they described as a "cafe for the global village," invoking the spirit of MarsJ McLuhan. ECI could be considered the first cybercafe, but with a crucial difl ence from today's cybercafes. While it served food, drinks, and teleconferenci ECI was primarily a cultural research lab. When few others had yet to see need, Galloway and Rabinowitz brought real-time networked collaborative n timedia environments to people without other access. ECI's projects addres multicultural communities and artists across the globe. By making cutting-e telecommunications tools available in a casual, artists'cafe space (rather ti on a campus or at a museum), ECI was the catalyst for much formal innoval in collaborative networked performance.

For Galloway and Rabinowitz, the cafe was the culmination of projects t dated to 1975, when they began their "Aesthetic Research in Telecommurt tions"—as they referred to their groundbreaking satellite art at the time, spired by the telematic experiments of Myron Krueger, they invited artisü col labórate in "a performance space with no geographic boundaries." In tlj live performances, the images of geographically dispersed artists were tr^ mitted via satellite to créate a composite performance video on a single sen The objective, as they explained, was "to demónstrate (for the first time), t several performing artists, all of whom would be separated by oceans and ge raphy, could appear and perform together in the same live image (the imag< place)."These investigations in "teleperformance" opened up new possibilities simultaneous theater events involving dancers, actors, and musicians networ across great distances.

Galloway and Rabinowitz's investigations with artists led them to expío variety of unscripted forms of communication using these tools. Perhaps ti best-known work in this vein is the 1980s *Hole-in-Space, a* two-way satellite hoo between Lincoln Center in New York and Century City in Los Angeles. La screens were set up outside at both locations, projecting the image of the en that gathered at the opposite place, bringing people three thousand miles aj face-to-face in real time. In effect, each screen became a window onto the oí location. Over three days, the project escalated into a frenzy of homecomii long lost siblings greeting one another, and transcontinental romances. *Ha Space* sparked an interest in new genres of telecommunications art for the In net, including MUDs, Net art, and networked installations. »

original idea, back in the 1970s, was to créate an electronic, multimedia mposite-image space in which people separated by distance, language, valúes, d culture could come together to collaborate. The image itself would become ilace that we named "virtual space," which differs from virtual and artificial re-ty because the people, places, and things are real-world Ítems; they're not ren-red by computen Our original research was íiinded by Corporation for Public oadcasting and National Endowment for the Arts, with support from NASA. We wanted performing artists to meet in composite-image space that mixed 2 images from remote places and presented the mix at each location so per-mers could see themselves on the same screen with their partners. That be-ne the premise for our subsequent work and experimentación. This sort of composite image space was explored in the early 1950s by Ernie vacs and Steve Alien. Kovacs would superimpose his live video image onto i clips and interact with the film characters. Alien would do improvisational nedy by superimposing his live studio image with live camera shots of un-pecting pedestrians outside the televisión studio.

We first explored composite-image space because we wanted to créate a pernance place with no geographical boundaries, in which we could collaborate i other artists. We wanted to explore the aesthetics and sense of presence in lared performance/multimedia environment, where people don't leave their igenous environments. That way people from varied creative and cultural kgrounds could help créate a new environment in which they would collab-e on an international scale.

tn designing such spaces, we look not only at their qualities and aesthetics, how people interact when they are disembodied and their image is their bassador." A virtual space creates social situations without tradicional rules iquette. The absence of the threat of physical harm makes people braver. Virspace diminishes our fears of interaction. Still, a person is offended when the al-space hand "touches" body parts that wouldn't be touched normally "in

lesh." In virtual space, we learn the extent to which we "own" our image. It ;s to the beliefs of some cultures; if you take a photograph of people, they beyou capture or "steal" part of their essence or soul. This is a violación of ¡ image. Anyone can experience this in virtual space when seeing their image ted by a person or object that occupies the same image space.

you define the aesthetic of the médium by defining the essence and iny of the médium, then the creation of "good" art, in the case of telecomcations, means you créate a situation that provides some íbrm of uuiiicadon between people and maximizes the technology's capabilities.

But there must be a quality of tensión that defines the "communication." Ifv don't créate tensión in the work, you're not really looking at the qualities of I médium, or the qualities t>f the art....

Hole-in-Space, from 1980, was a live two-way satellite connection using vid screens to project life-size images. Without public announcement, we instaU *Hole-in-Space* on the street near New York City's Lincoln Center and in a disp window at a Los Angeles department store in Century City. Both screens coi accommodate the images of about 15 people. People could converse with p< pie in the other city as if they were standing orí the same córner. *Hole-in-Spt* took place over three evenings. On the first night, people simply discovered They went home arid told their friends, who showed up for the second evenii when it was also announced on TV in both locations. On the third night, fai lies from miles away drove into the cities with cars full of kids to meet up with r atives on the other coast whom they hadn't seen in years....

the cafe as cultural community center

We wanted to créate an environment for creative people to enjoy one-to-one a group-to-group exchanges. That's where Electronic Cafe comes in. The fl¡ ship cafe is in southern California, in Santa Monica, networked with Electroi Cafe Affiliates in San Francisco, New York City, Oakland and Santa Cruz, Cs fornia. Santa Fe, Chicago, Pittsburgh, Vancouver, Toronto, París, Berlin, Jap¡ Seoul. Managua, Barcelona, and Budapest. We're building human networks an international. cross-cultural, multidisciplinary scale. These networks cona of people who are getting to know each other and the technology that maintai their relationship. They're trymg to creatively anímate that technology by < gaging in new types of conversation.

The point of Electronic Cafe is to créate a community commons. The mosphere encourages friendly conversation and serves as an amenity to I telecommunications technology. And our events typically cost $3-$5 to alten

In 1984 we were commissioned by the L.A. Museum of Contemporary / (MOCA) to créate a seven-week project for the L.A. Olympic Arts Festival. TI was the birth of the Electronic Cafe concept. We linked MOCA with five diveí L.A. communities through a telecom system, computer datábase, and dial-i image bank. People in the Korean community, Hispanic community, black coi munity, and artsy beach community could send each other slow-scan video images, draw or write together with an electronic writing tablet, print pictures with the video printer, enter and retrieve information and ideas in the computer datábase, and store or retrieve images on a videodisc recorder that held 20,000 images. Electronic Cafe Artists-in-Residence helped people use the systems, solicit performance pieces, and transmit musical events.

These events propelled the network into a dynamic, inspirational existence. For example, Los Angeles's Korean community and black community traditionally are at odds with each other. As they met and got to know each other through the network, they wanted to visit each other! When you can make eye contad and establish a creative relationship with someone, you usually want to meet and touch them. At first people talked informally over the network, then created something together, and in many cases, ended up arranging in-person meetings. Today, each Electronic Cafe contains the low-cost Commodore Amiga com-puters, which have audio and video capabilities. We also use black-and-white, still-frame videophones (we cali them "vidphones"); color still-frame vidphones; video projectors; IBM PC-compatible and Macintosh II computers containing special circuit boards that capture video images; modems; computer printers; fax machines; and software for telecommunications, desktop publishing, datábase management, and graphics. We also have múltiple telephone lines. Not all of the Electronic Cafes own video and color printers, but some locations consider them essential for documenting events.

All of this hardware and software lets EC Network affiliates exchange still-frame video images and computer graphics, enjoy video and audio teleconfer-encing and two-way drawing and writing in shared-screen presentations, exchange computer files, programs, electronic mail, and black-and-white images and/or text, and conduct real-time "chats" via computer. People who own videophones or computers are welcome to dial in and join the network. We invite people to come in and encounter the technology in a nonintimidating environment. Our Robot Research 1200C video transmission system sends color or black-md-white images over phone lines (a color image measuring 256 X 256 pixels akes 36 seconds, while a black-and-white image of the same resolution sends in *14* seconds). Images are received by another Robot 1200C or Commodore ^miga with special software. Our vidphones transmit black-and-white images *vith* an average 100 X 100 pixel resolution in seven or eight seconds. These vid-ihones (by Panasonic and Mitsubishi) no longer are manufactured, but other ompanies build similar systems.

One typical ECI event was *Earth Day Global Link '90,* the only truly ínter-active global event to occur on Earth Day. It involved connections and telepe formances with Moscow, Nicaragua, Berlin, and Japan. In the connection wil Moscow, people discussed environmental problems and artists performed t< gether. Children in L.A. asked the Russians, "Do you have boles in your ozorn too?"

In another Electronic Cafe presentation, a dancer named Dawn Stoppiell used technology to genérate music on a Macintosh-based MIDI system and trij ger vidphones that sent her image to a New York City site. Working with Dawi computer musician Mark Coniglio of the Center for Experiments in Art, Infoi mation, and Technology (based at California Institute of the Arts) developed Macintosh II program, MIDI Dancer. Using MIDI Dancer and wearing wirela motion-monitoring devices on her arms and around her waist, Dawn transmi ted data about her movements to the Mac. Dawn's motions controlled the pn viously scored music, synchronizing it to her cadenee, controlled the lighting an microphone levéis, and determined when her image was captured and transmi ted to the New York location.

In a current Electronic Cafe project, *The 21st Century Odyssey,* performam artist Barbara T. Smith is traveling around the world with a portable vidphou system to connect with Electronic Cafe and the artists and other people sh meets in her journeys. Her virtual spaces also include Bio Sphere 2 resident D Roy Walford, communicating with us and the world through his ECI vidphon system.

Today ECI is testing limited-motion video systems and groupware. We ai exploring ways in which digital networks allow group-to-group activities an enable a person to control objects in remote rooms.

integration and access

If there is one word that defines Electronic Cafe, it is *integration:* integration (technology into our social fabric; integration of distinct cultures and commun ties, the arts, and the general public; and integration of art forms.

When we put integration capabilities in a community center where peopl can witness the "creative animation" of technology, we can start to libérate pet ple's imaginations. When artists explore this technology, we start pushing the Un its of technology. We créate a culture that defines how the technology can b used and encourages cross-cultural collaborations, problem-solving, an decision-making. Our hope is to créate a cultural environment that helps peop] around the world articúlate what they want in their future and determine how to §et there írom here.

The ability to pick up a telephone and talk to a person is the most powerful magic created by contemporary society. It is the only mechanism that lets us manage a system as large as a planet. We must recognize that this is sacred, and Decome a "tele-species." Through Electronic Cafes and the use of telecommu-lications technology, we hope to foster new kinds of artistic collaboration and ex-jerimentation that will support the tele-species.

We want to make teleconferencing systems nonintimidating and accessible to jeople who don't work within corporations. We want to get the technology to as nany people as possible, articúlate the ramifications, define the aesthetics, and opple political roadblocks. Corporate culture is not going to provide models or pplications broad enough to visualize the technology's cultural application. We mst acculturate it ourselves.

If the arts are to take a role in shaping and humanizing emerging technolog-:al environments, individuáis and arts constituencies must start to imagine at a mch larger scale of creativity. If you look at the aesthetic quality of the commu-ication and you're true to your art form and your art logic, then you naturally ut one foot in front of the other ... and the art logic marches you right out of le art institutions and into life..

Pavel Curtís

35» "Mudding: Social Phenomena in Text-Based Virtual Realitíes" (1992)

***Pavel Curtís. Photo by Anne Hamersky, © Anne Hamersky,* Fast Company Magazine.**

"The emergence of MUDs has created a new kind of social sphere, both líke and radícally unlike the environments that have existed before. As they become more and more popular and more widely accessible, ¡t appears likely that an increasingly significant proportion ofthe population will at least become familiar with mudding and perhaps become frequent partidpants in text-based virtual realities."

"Muddmg: Social Phenomena in Text-Based Virtual Realities"

Pavel Curtís, a computar scientistat Xerox PARC (Palo Alto Research Cen-:er), created one of the first popular on-line role-playing environments, LambiaMOO, in 1991. Known as a MUD (the acronym stands for Multi-User 3ungeons), LambdaMOO is a text-only fantasy realm that is descended from oleplaying games from the 1970s such as "Dungeons and Dragons" (henee the lungeon allusion in MUD). After presiding over this experimental digital envionment for one year as its creator, administrator, and self-proclaimed "wiz-ird," Curtís documented his observations of the evolving social, cultural, and 'sychological effects of interaction in cyberspace. While not the first of its kind, .ambdaMOO is perhaps the most famous text-based virtual environment, disected and analyzed by media theorists, sociologists, and psychologists who see : as fertile breeding ground for a new hybrid form of literature, live perfor-lance, cinema, and interactive story making.

In his essay, Curtís directs our attentíon to LambdaMOO's narrative char;teríst¡cs. Unlike conventional story structures, MUDs do not rely on defined ots with clear objectives. Rather, through the freewheeling dynamics of improsed dialogue and unrehearsed interactivity, participants lose themselves in their les and collaborate in a form of collective authorship. Shielded (and even libated) by the anonymity of their characters, players improvise their own conrsations, story lines, props, and settings; they pursue their own adventures, and periment with a myriad of altérnate identities; sometimes they even switch genr and, occasionally, species. LambdaMOO has served as a model for thousands MUDs that have since sprung from the Internet and the World Wide Web. U Ds are characterized by a tightly knit—though globally dispersed—commuy of characters engaged in an ongoing dialogue that combines the aimlessness nomadíc wandering with the focused creativity of world building.There is no niscient narrator, no central author, in LambdaMOO, despite the shadowy sence of its "wizard,"
Pavel Curtís.

While Curtís emphasízes the richness of the text-based virtual world —re-ing to Marshall McLuhan's concept of the "cool" médium in whích the wer's imagination is engaged to ^complete" the experíence of the lowílution environment—graphíc, multimedia virtual worlds have supplanted r textual ancestors. Nonetheless, Curtís's observation of on-line role playing virtual communities are fundamental to our understanding of the social imations of networked alternative realities, now popular in the form of chat ns, teleconferencing, and email Listservs. »

around the world articúlate what they want in their future and determine how to get there from here.

The ability to pick up a telephone and talk to a person is the most powerful magic created by contemporary society. It is the only mechanism that lets us manage a system as large as a planet. We must recognize that this is sacred, and become a "tele-species." Through Electronic Cafes and the use of telecommu-nications technology, we hope to foster new kinds of artistic collaboration and ex-perimentation that will support the tele-species.

We want to make teleconferencing systems nonintimidating and accessible to people who don't work within corporations. We want to get the technology to as many people as possible, articúlate the ramifications, define the aesthetics, and topple political roadblocks. Corporate culture is not going to provide models or applications broad enough to visualize the technology's cultural application. We must acculturate it ourselves.

If the arts are to take a role in shaping and humanizing emerging technological environments, individuáis and arts constituencies must start to imagine at a much larger scale of creativity. If you look at the aesthetic quality of the commu-nication and you're trae to your art form and your art logic, then you naturally put one foot in front of the other ... and the art logic marches you right out of the art institutions and into life..

```
retched across the hall. There are doorways leading

 the north and south.
ju see a sign hanging from the middle of the rope here.
read sign
lis point marks the end of the currently-occupied
Drtion of the house. Guests proceed beyond this point
 their own risk.
the residents
jo east
su step disdainfully over the velvet rope and enter
le dusty darkness of the unused portion of the house.
```

Three major factors distinguish a MUD from an Adventure-style computer game, lough:

3. A MUD is not goal-oriented; it has no beginning or end, no "score," andno notion of "winning" or "success." In short, even though users of MUDsare commonly called players, a MUD isn't really a game at all.

4. A MUD is extensible from within; a user can add new objects to the datá base such as rooms, exits, "things," and notes. Certain MUDs, including the one I run, even support an embedded programming language in whicha user can describe whole new kinds of behavior for the objects they créate.

5. A MUD generally has more than one user connected at a time. All of theconnected users are browsing and manipulating the same datábase andcan encounter the new objects created by others. The múltiple users on aMUD can communicate with each other in real time.

is last factor has a profound effect on the ways in which users interact with the tem; it transforms the activity from a solitary one into a social one. Most inter-player communication on MUDs follows rules that fit within the nework of the virtual reality. If a player "says" something (using the say com-id), then every other player in the same room will "hear" them. For example, pose that a player named Munchkin typed the command

```
say Can anyone hear me?
```

In Munchkin would see the feedback

```
¥ou say, "Can anyone hear me?"
```

every other player in the same room would see

```
klunchkm says, "Can anyone hear me?"
```

Similarly, the emote command allows players to express various forms of "non verbal" communication. If Munchkin types

emote smiles.

then every player in the same room sees Munchkin smiles.

Most interplayer communication relies entirely on these two commands.[3]

There are two circumstances in which the realistic limitations of say ant emote have proved sufficiently annoying that new mechanisms were developed It sometimes happens that one player wishes to speak to another player in th< same room. but without anyone else in the room being aware of the communication. If Munchkin uses the whisper command

whisper "I wish he'd just go away ..." to Frebble then only Frebble will see

Munchkin whispers, "I wish he'd just go away ..."

The other players in the room see nothing of this at all.

Finally, if one player wishes to say something to another who is connected to the MUD but currently in a difFerent and perhaps "remote" room, the page command is appropriate. It is invoked with a syntax very like that of the whisper command and the recipient sees output like this:

You sense that Munchkin is looking for you ín The Hall. He pages, "Come see this clock, it's tres cool!"

Aside from conversation, MUD players can most directly express themselves in three ways: by their choice of player ñame, by their choice of gender, and by their self-description.

When a player first connects to a MUD, they choose a ñame by which the other players will know them. This choice, like almost all others in MUDs, is not cast in stone; any player can rename themself at any time, though not to a ñame currently in use by some other player. Typically, MUD ñames are single words, in contrast to the longer "full" ñames used in real life.

Initially, MUD players appear to be neuter; automatically generated messages that refer to such a player use the family of pronouns including "it," "its," etc. Players can choose to appear as a difFerent gender, though, and not only male or female. On many MUDs, players can also choose to be plural (appearing to be a kind of "colony" creature: "ChupChups leave the room, closing the door behind them"), or to use one of several sets of gender-neutral pronouns (e.g., "s/he," "him/her" and "his/her," or "e," "em" and "eir").

Every object in a MUD optionally has a textual description which players can view with the look command. For example, the description of a room is automatically shown to a player when they enter that room and can be seen again just by typing "look." To see another player's description, one might type "look Bert." Players can set or change their descriptions at any time. The lengths of player descriptions typically vary from short one-liners to dozen-line paragraphs.

Aside from direct communication and responses to player commands, mes-sages are printed to players when other players enter or leave the same room, when others connect or disconnect and are already in the same room, and when objects in the virtual reality have asynchronous behavior (e.g., a cuckoo clock chiming the hours).

MUD players typically spend their connected time socializing with each other, exploring the various rooms and other objects in the database, and adding new such objects of their own design. They vary widely in the amount of time they spend connected on each visit, ranging from only a minute to several hours; some players stay connected (and almost always idle) for days at a time, only oc-casionally actively participating.

This very brief description of the technical aspects of mudding suffices for the purposes of this paper. It has been my experience, however, that it is quite diffi-cult to properly convey the "sense" of the experience in words. Readers desiring more detailed information are advised to try mudding themselves, as described in the final section of this paper.

2 social phenomena observed on one MUD

> Man is the measure.[4]
>
> —E. M. Forster

In October of 1990,1 began running an Internet-accessible MUD server on my personal workstation here at PARC. Since then, it has been running conünuously, with interruptions of only a few hours at most. Injanuary of 1991, the existence of the MUD (called LambdaMOO[5]) was announced publicly, vía the Usenet newsgroup rec.games.mud. As of this writing, well over 3,500 difieren! players
i\>a raveiiums

have connected to the server from over a dozen countries around the world and, at any given time, over 750 players have connected at least once in the last week. Recent statistics concerning the number of players connected at a given time of day (Pacific Standard Time) appear below.

```
42.  a.m.  ************** 10-1/2
43.  a.m.  ***************** 12/1/4
44.  a.m.  ******************* 14
/ 3 .in.  **************************
21~1/4
28.  a.m.  ******************************
21-1/4
29.  a.m.
*********************************** 25-1/4

11.  a.m.
*************************************** 28
12.  a.m.
***************************************
****** 32—1/4noon
**************************************
************** 37

11.  p.m.

*******************************************
************** 41-1/4
12.  p.m.

*******************************************
************* 39-3/4
13.  p.m.

******************************************
****** j 5
14.  p.m.

*******************************************
************* 39—1/2
15.  p.m.

*******************************************
************** 40-3/4
16.  p.m.
```

```
*******************************************
************* 39-3/4
17.  p.m.

*******************************************
************** 40-1/2
18.  p.m.

*******************************************
*****************

     42-1/2
9p.m.
*******************************************
*******************

     44-1/4
12.  p.m.
*******************************************
********* 37-3/4
13.  p.m.
*********************************
************ 31
midnight************************
*************** 26-3/4

1.   a.m.
 ****************************************
20-3/4
2.   a.m.  ******************* 13-3/4
3.   a.m.  ************** 10-3/4
4.   a.m.  ************* 10-1/2
```

LambdaMOO is clearly a reasonably active place, with new and oíd players com-ing and going frequently throughout the day. This popularity has provided me with a position from which to observe the social patterns of a fairly large and diverse MUD diéntele. I want to point out to the reader, however, that I have no formal training in sociology, anthropology, or psychology, so I cannot make any claims about methodology or even my own objectivity. What I relate below ia merely my personal observations made over a year of mudding. In most cases, my discussions of the motivations and feelings of individual players is based upon in-MUD conversations with them; I have no means of checking the veracity of their statements concerning their real-life genders, identities, or (obviously) feelings. On the other hand, in most cases, I also have no reason to doubt them.

I have grouped my observations into three categories: phenomena related to the behavior and motivations of individual players, phenomena related to ínter-actions between small groups of players (especially observations concerning MUD conversation), and phenomena related to the behavior of a MUD's com-munity as a whole.

Cutting across all of these categories is a recurring theme to which I would like to draw the reader's attention in advance. Social behavior on MUDs is in some ways a direct mirror of behavior in real life, with mechanisms being drawn nearly unchanged from real-life, and in some ways very new and different, taking root in the new opportunities that MUDs provide over real life.

2.1 Observations about individuáis

The Mudding Population The people who have an opportunity to connect to LambdaMOO are not a representative sample of the world population; they all read and write English with at least passable proficiency and they have access to the Internet. Based on the ñames of their network hosts, I believe that well over 90% of them are affiliated with colleges and universities, mostly as students and, to a lesser extent, mostly undergraduates. Because they have Internet access, it might be supposed that the vast majority of players are involved in the comput-ing field. but I do not believe that this is the case. It appears to me that no more than half (and probably less) of them are so employed; the increasing general availability of computing resources on college campusas and in industry appears to be having an effect, allowing a broader community to participate.

In any case, it appears that the educational background of the mudding community is generally above average and it is likely that the economic background is similarly above the norm. Based on my conversations with people and on the ñames of those who have asked to join a mailing list about programming in LambdaMOO, I would guess that over 70% of the players are male; it is very difficult to give any firm justification for this number, however.

Player Presentation As described in the introduction to mudding, players have a number of choices about how to present themselves in the MUD; the first such decisión is the ñame they will use. Some of the ñames used by players on LambdaMOO are shown below.

Gemba	Gary_Severn	Ford	Frand
Maya	Rincewind	yduj	funky
Foodslave	Arthur	EbbTide	Anathae
Satán	byte	Booga	tek

Toon li'ir
Grump yrx

Pavel Curtís

chupchups	waffle	Miranda	Gus	Merlin
Moonlight	MrNatural	Winger	Drazz'zt	Kendal
Redjack	Snooze	Shin	lostboy	foobar
Ted Logan	Xephyr	King_Claudius	Bruce	Puff
Dirque	Coyote	Vastín	Player	Cool
Amy	Thorgeir	Cyberhuman	Gandalf	blip
Jayhirazan	Firefoot	JoeFeedback	ZZZzzz . . .	Lyssa
Avalar	zipo	Blackwinter	viz	Kilik
Maelstorm	Love	Terryann	Chrystal	arkanoiv

One can pick out a few common styles for ñames (e.g., ñames from or ir spired by myth, fantasy, or other literature, common ñames from real life, ñame of concepts, animáis, and everyday objects that have representative connotations etc.), but it is clear that no such category includes a majority of the ñames. Not that a significant minority of the ñames are in lower case; this appears to be a styl istic choice (players with such ñames describe the practice as "cool") and not, a might be supposed, an indication of a depressed ego.

Players can be quite possessive about their ñames, resenting others wh(choose ñames that are similarly spelt or pronounced or even that are taken fron the same mythology or work of literature. In one case, for example, a playe: ñames "ZigZag" complained to me about other players taking the ñame; "ZigZag!"and"Zig."

The choice of a player's gender is, for some, one of great consequence anc forethought; for others (mosdy males), it is simple and without any questions. Foi all that diis choice involves the fewest options for the player (unlike their ñame or description, which are limited only by their imagination), it is also the choice that can genérate the greatest concern and interest on the part of other players.

As I've said before, it appears that the great majority of players are male and the vast majority of them choose to present themselves as such. Some males, however, taking advantage of the relative rarity of females in MUDs, present themselves as female and thus stand out to some degree. Some use this distinc-tionjust for the fun of deceiving others, some of these going so far as to try to entice male-presenting players into sexually explicit discussions and interactions. This is such a widely noticed phenomenon, in fact, that one is advised by the common wisdom to assume that any flirtatious female-presenting players are, in real life, males. Such players are often subject to ostracism based on this as-sumption.

Some MUD players have suggested to me that such transvestite flirts are per-s acting out their own (latent or otherwise) homosexual urges or fantasies, tak- advantage of the perfect safety of the MUD situation to see how it feels to ap- ach other men. While I have had no personal experience talking to such rers, let alone the opportunity to delve into their motivations, the idea strikes as plausible given the other ways in which MUD anonymity seems to free peo-from their inhibitions. (I say more about anonymity later on.) Other males present themselves as female more out of curiosity than as an at->pt at deception; to some degree, they are interested in seeing "how the other :"lives," what it feels like to be perceived as female in a community. From what n tell, they can be quite successful at this.

Female-presenting players report a number of problems. Many of them have 1 me that they are frequently subject both to harassment and to special treat-it. One reported seeing two newcomers arrive at the same time, one male- senting and one female-presenting. The other players in the room struck up versations with the putative female and offered to show her around but com- ely ignored the putative male, who was left to his own devices. In addition, probably due mostly to the number of female-presenting males hears about, many female players report that they are frequently (and some-ís quite aggressively) challenged to "prove" that they are, in fact, female. To best of my knowledge, male-presenting players are rarely if ever so chal-;ed.

Because of these problems, many players who are female in real life choose resent themselves otherwise, choosing either male, neuter, or gender-neutral louns. As one might expect, the neuter and gender-neutral presenters are still ect to demands that they divulge their real gender.

Some players apparently find it quite difficult to interact with those whose gender has been called into question; since this phenomenon is rarely man-in real life, they have grown dependent on "knowing where they stand," on ving what gender roles are "appropriate." Some players (and not only males) feel that it is dishonest to present oneself as being a different gender than in life; they report feeling "mad" and "used" when they discover the deception. While I can spare no more space for this topic, I enthusiastically encourage nterested reader to look up Van Gelder's fascinating article[6] for many more iples and insights, as well as the story of a remarkably successful deception electronic transvestism."

The final part of a player's self-presentation, and the only part involving e, ÍS the player's description. This is where players can, and often do, es- sh the details of a persona or role they wish to play in the virtual reality. It is *also* a significant factor in other players' first impressions, since new players ai commonly looked at soon after entering a common room.

Some players use extremely short descriptions, either intending to be cry] tic (e.g., "the possessor of the infinity gems") or straightforward (e.g., "^ average-sized dark elf with lavender eyes") or, often, [they are] just insufficiend motivated to create a more complex description for themselves. Other players g to great efforts in writing their descriptions; one moderately long example appears below.

> You see a quiet, unassuming figure, wreathed in an oversized, dull-green Army jacket which is pulled up to nearly conceal his face. His long, unkempt blond hair blows back from his face as he tosses his head to meet your gaze. Small round gold-rimmed glasses, tinted slightly grey, rest on his nose. On a shoulder strap he carnes an acoustic guitar and he lugs a backpack stuffed to overflowing with sheet music, sketches, and computer printouts. Under the coat are faded jeans and a T-shirt reading "Paranoid CyberPunks International." He meets your gaze and smiles faintly, but does not speak with you. As you surmise him, you notice a glint of red at the rims of his blue eyes, and realize that his canine teeth seem to protrude slightly. He recoils from your look of horror and recedes back into himself.

A large proportion of player descriptions contain a degree of wish fulfil] ment; I cannot count the number of "mysterious but unmistakably powerful" fig ures I have seen wandering around in LambdaMOO. Many players, it seems, ari taking advantage of the MUD to emulate various attractive characters from fie tion.

Given the detail and contení of so many player descriptions, one might expec to find a significant amount of role-playing, players who adopt a coherent char acter with features distinct from their real-life personalities. Such is rarely th< case, however. Most players appear to tire of such an effort quickly and simply in teract with the odiers more-or-less straightforwardly, at least to the degree on< does in normal discourse. One factor might be that the roles chosen by playen are usually taken from a particular creative work and are not particularly viabh as characters outside of the context of that work; in short, the roles don't mala sense in the context of the MUD.

A notable exception to this rule is one particular MUD Tve heard of, callee "PernMUSH." This appears to *be* a rigidly maintained simulacrum of the worlc described in Ann McCaffrey's celebrated "Dragón" books. All players there hav« ñames that fit the style of the books and all places built there are consistent witt what is shown in the series and in various fan materials devoted to it. PernMUSH apparendy holds frequent "hatchings" and other social events, also derived in great detail from McCaffrey's works. This exception probably succeeds only be-cause of its single-mindedness; with every player providing the correct context for every other, it is easier for everyone to stay more-or-less "in character."

Player Anonymity It seems to me that the most significant social factor in MUDs is the perfect anonymity provided to the players. There are no commands available to the players to discover the real-life identity of each other and, in-deed, technical considerations make such commands either very difficult or im-possible to implement.

It is this guarantee of privacy that makes players' self-presentation so impor-tant and, in a sense, successful. Players can only be known by what they explic-idy project and are not "locked into" any factors beyond their easy control, such as personal appearance, race, etc. In the words of an oíd military recruiting com-mercial, MUD players can "be all that you can be."[7]

This also contributes to what might be called a "shipboard syndrome," the feeling that since one will likely never meet anyone from the MUD in real life, there is less social risk involved and inhibitions can safely be lowered.

For example, many players report that they are much more willing to strike up conversations with strangers they encounter in the MUD than in real life. One obvious factor is that MUD visitors are implicitly assumed to be interested in conversing, unlike in most real world contexts. Another deeper reason, though, is that players do not feel that very much is at risk. At worst, if they feel diat they've made an utter fool of themself, they can always abandon die character and créate a new one, losing only the ñame and the effort invested in socially estab-lishing the oíd one. In effect, a "new léase on life" is always a ready option.

Players on most MUDs are also emboldened somewhat by the fact that diey iré immune from violence, both physical and virtual. The permissions systems of all MUDs (excepting those whose whole purpose revolves around adventur-ing and the slaying of monsters and other players) generally prevent any player From having any kind of permanent effect on any other player. Players can cer-:ainly annoy each other, but not in any lasting or even moderately long-lived nanner.

This protective anonymity also encourages some players to behave irreiponsibly, rudely, or even obnoxiously. We have had instances of severe and re->eated sexual harassment, crudity, and delibérate offensiveness. In general, such :ruelty seems to be supported by two causes: the oífenders believe (usually correcdy) that they cannot be held accountable for their actions in the real world, and the very same anonymity makes it easier for them to treat other players imper-sonally, as other than real people.

Wizards Usually, as I understand it, societies cope with offensive behavior by various group mechanisms, such as ostracism, and I discuss this kind of effect in detail in Section 2.3. In certain severe cases, however, it is left to the "authorities" or "pólice" of a society to take direct action, and MUDs are no different in this respect.

On MUDs, it is a special class of players, usually called wizards or (less frequently) gods, who fulfill both the "authority" and "pólice" roles. A wizard is a player who has special permissions and commands available, usually for the pur-pose of maintaining the MUD, much like a "system administrator" or "super-user" in real-life computing systems. Players can only be transformed into wizardsby other wizards, with the maintainer of the actual MUD server computer pro-gram acting as the first such

2.2 Observations about small groups

MUD Conversation The majority of players spend the majority of their active time on MUDs in conversation with other players. The mechanisms by which those conversations get started generally mirror those that opérate in real life. though sometimes in interesting ways.

Chance encounters between players exploring the same parts of the datábase are common and almost always cause for conversation. As mentioned above. the anonymity of MUDs tends to lower social barriers and to encourage players to be more outgoing than in real life. Strangers on MUDs greet each other with the same kinds of questions as in real life: "Are you new here? I don't think we've met." The very first greetings, however, are usually gestural rather than verbal: "Munchkin waves. Lorelei waves back."

The @who (or WHO) command on MUDs allows players to see who else is currently connected and, on some MUDs, where those people are. An example of the output of this command appears below.

```
    PLAYER ÑAME     CONNECTED     IDLETIME      LOCATION
Haakon (#2) Lynx(#8910) Garin (#23393)
3 days a minute an hour
a second 2 seconds 2 seconds
Lambda's Den Lynx' Abode Carnival Grounds
```

PLAYERNAME CONNECTED IDLETIME LOCATION

Gilmore (#19194) an hour	10 seconds	Heart of Darkness
TamLin(#21864) anhour	21 seconds	Heart of Darkness
Quimby (#23279) 3 minutes	2 minutes	Quimby's room
koosh (#24639) 50 minutes	5 minutes	Corridor
Nosredna (#2487) 7 hours	36 minutes	Nosredna's Hideaway
yduj (#68) 7 hours	47 minutes	Hackers' Heaven
Zachary (#4670) an hour	an hour	Zachary's Workshop
Woodlock (#2520) 2 hours	2 hours	Woodlock's Room

Total: 11 players, 6 of whom have been active recently.

This is, in a sense, the MUD analog of scanning the room in a real-life gathering to see who's present....

Other Small-Group Interactions I would not like to give the impression that conversation is the only social activity on MUDs. Indeed, MUD society appears to have most of the same social activities as real life, albeit often in a modified form. As mentioned before, PernMUSH holds large-scale, organized social gath-erings such as "hatchings" and they are not alone. Most MUDs have at one time or another organized more or less elabórate parties, often to celébrate notable events in the MUD itself, such as an anniversary of its founding. We have so far had only one or two such parties on LambdaMOO, to celébrate the "opening" of some new área built by a player; if there were any other major parties, I cer-tainly wasn't invited!

One of the more impressive examples of MUD social activity is the virtual wedding. There have been many of these on many different MUDs; we are in the process of planning our first on LambdaMOO, with me officiating in my role as irchwizard.

I have never been present at such a ceremony, but I have read logs of the conversations at them. As I do not know any of the participants in the ceremonies Tve read about, I cannot say much for certain about their emotional content. As in real life, they are usually very happy and celebratory occasions with n intriguing undercurrent of serious feelings. I do not know and cannot even peculate about whether or not the main participants in such ceremonies are usually serious or not, whether or not the MUD ceremony usually (or even ever) urrors another ceremony in the real world, or even whether or not the bride and room have ever met outside of virtual reality.

In the specific case of the upcoming LambdaMOO wedding, the participants first met on LambdaMOO, became quite friendly, and eventually decidec to meet in real life. They have subsequently become romantically involved in th< real world and are using the MUD wedding as a celebration of that fact. This phe nomenon of couples meeting in virtual reality and then pursuing a real-life reí» tionship is not uncommon; in one notable case, they did this even though one oí them lived in Australia and the other in Pittsburgh!

It is interesting to note that the virtual reality wedding is not specific to thí kinds of MUDs Tve been discussing; Van Gelder[8] mentions an on-line receptior on CompuServe and weddings are quite common on Habitat,[9] a half-graphicai half-textual virtual reality popular in Japan.

The very idea, however, brings up interesting and potentially importan! questions about the legal standing of commitments made only in virtual reality. Suppose, for example, that two people make a contract in virtual reality. Is tht contract binding? Under which state's (or country's) laws? Is it a written or verbal contract? What constitutes proof of signature in such a context? I suspect thal our real-world society will have to face and resolve these issues in the not-too-distant íuture.

Those who frequent MUDs tend also to be interested in games and puzzles, so it is no surprise that many real-world examples have been implemented inside MUDs. What may be surprising, however, is the extent to which this is so.

On LambdaMOO alone, we have machine-mediated Scrabble, Monopoly, Mastermind, Backgammon, Ghost, Chess, Go, and Reversi boards. These attracl small groups of players on occasion, with the Go players being the most com-mitted; in fact, there are a number of Go players who come to LambdaMOO only for that purpose. I say more about these more specialized uses of social virtual re-alities later on. In many ways, though, such games so far have little, if anything, to offer over their real-world counterparts except perhaps a better chance of find-ing an opponent.

Perhaps more interesting are the other kinds of games imported into MUDs from real life, the ones that might be far less feasible in a non-virtual reality. A player on LambdaMOO, for example, implemented a facility for holding food fights. Players throw food Ítems at each other, attempt to duck oncoming Ítems, and, if unsuccessful, are "splattered" with messes that cannot easily be removed. After a short interval, a semi-animate "Mr. Clean" arrives and one-by-one removes the messes from the participants, turning them back into the food Ítems from which they carne, ready for the next fight.

Although the game was rather simple to implement, it has remained enormously popular nearly a year later.

Another player on LambdaMOO created a trainable Frisbee, which any

player could teach to do tricks when they threw or caught it. Players who used the Frisbee seemed to take great pleasure in trying to out-do each other's trick de-scriptions. My catching description, for example, reads "Haakon stops the fris-bee dead in the air in front of himself and then daintily plucks it, like a flower." I have also heard of MUD versions of paint-ball combat and fantastical games of Capture the Flag.

2.*3 Observations about the MUD community as a whole*

MUD communities tend to be very large in comparison to the number of play-irs actually active at any given time. On LambdaMOO, for example, we have be-ween 700 and 800 players connecting in any week but rarely more than 40 ¿multaneously. A good real-world analog might be a bar with a large number of regulars," all of whom are transients without fixed schedules.

The continuity of MUD society is thus somewhat tenuous; many pairs of ac-ive players exist who have never met each other. In spite of this, MUDs do be-ome true communities after a time. The participants slowly come to consensus bout a common (private) language, about appropriate standards of behavior, and bout the social roles of various public areas (e.g., where big discussions usually appen, where certain "crowds" can be found, etc.)....

It should be noted that different MUDs are truly different communities and ave different societal agreements concerning appropriate behavior. There even dst a few MUDs where the only rule in the social contract is that there is no so-al contract. Such "anarchy" MUDs have appeared a few times in my experience id seem to be quite popular for a time before eventually fading away. These are the main points of LambdaMOO manners:

3. Be polite. Avoid being rude. The MOO is worth participating in becauseit is a pleasant place for people to be. When people are rude or nasty to oneanother, it stops being so pleasant.

4. "Revenge is ours," sayeth the wizards. If someone is nasty to you, please ei-ther ignore it or tell a wizard about it. Please don't try to take revenge on theperson; this just escalates the level of rudeness and makes the MOO a lesspleasant place for everyone involved.

Respect other players' sensibilities. The participants on the MOO come from a wide range of cultures and backgrounds. Your ideas about what constitutes offensive speech or descriptions are likely to differ from those of other players. Picase keep the text that players can casually run across as free of potentially-offensive material as you can.

Don't spoof. Spoofing is loosely defined as "causing misleading output to be printed to other players." For example, it would be spoofing for anyone but Munchkin to print out a message like "Munchkin sticks out bis tongue at Potrzebie." This makes it look like Munchkin is unhappy with Potrzebie even though that may not be the case at all.

Don't shout. It is easy to write a MOO command that prints a message to every connected player. Picase don't.

Only teleport your own things. By default, most objects (including other players) allow themselves to be moved freely from place to place. This fact makes it easier to build certain useíul objects. Unfortunately, it also makes it easy to annoy people by moving them or their objects around without their permission. Picase don't.

Don't teleport silently or obscurely. It is easy to write MOO commands that move you instantly from place to place. Please remember in such programs to print a clear, understandable message to all players in both the place you're leaving and the place you're going to.

Don't hog the serven The server is carefully shared among all of the connected players so that everyone gets a chance to execute their commands. This sharing is, by necessity, somewhat approximate. Please don't abuse it with tasks that run for a long time without pausing.

Don't waste object numbers. Some people, in a quest to own objects with "interesting" numbers (e.g., #17000, #18181, etc.) have written MOO programs that loop forever, creating and recycling objects until the "good' numbers come up. Please don't do this

3 the prospects for mudding in the future

> The clumsy system of public gatherings had been long since abandonad; neither Vashti ñor her audience stirred from their rooms. Seated in her arm-chair, she spoke, while they in their arm-chairs heard her, fairly well, and saw her, fairly well.
>
> -E. M. Forster[10]

It is substantially easier for players to give themselves vivid, detailed, and interesting descriptions (and to do the same for the descriptions and behavior of the new objects they créate) in a text-based system than in a graphics-based one. In McLuhan's terminology,[11] this is because MUDs are a "cold" médium, while lore graphically-based media are "hot"; that is, the sensorial parsimony of plain ;xt tends to entice users into engaging their imaginations to fill in missing details 'hile, comparatively speaking, the richness of stimuli in fancy virtual realities has n opposite tendency, pushing users' imaginations into a more passive role. I Iso find it difficult to believe that a graphics-based system will be able to compete with text for average users on the metric of believable detail per unit of ef->rt expended; this is certainly the case now and I see little reason to believe it will change in the near future.

Finally, one of the great strengths of MUDs lies in the users' ability to cusimize them, to extend them, and to specialize them to the users' particular ;eds. The case with which this can be done in MUDs is directly related to the ct that they are purely text-based; in a graphics-based system, the overhead of eating new moderate-quality graphics would put the task beyond the inclina>ns of the average user. Whereas, with MUDs, it is easy to imagine an almost artrarily small community investing in the creation of a virtual reality that was ily customized for that community, it seems very unlikely that any but the •gest communities would invest the greatly-increased effort required for a icier system.

CONCLUSIONS

> Vashti was seized with the terrors of direct experience. She shrank back into her room, and the wall closed up again.
>
> -E. M. Forster[12]

The emergence of MUDs has created a new kind of social sphere, both like and ically unlike the environments that have existed before. As they become more 1 more popular and more widely accessible, it appears likely that an increas-y significant proportion of the population will at least become familiar with iding and perhaps become frequent participants in text-based virtual reali-

It thus behooves us to begin to try to understand these new societies. to make ¡e of these electronic places where we'll be spending increasing amounts of time, both doing business and seeking pleasure. I would hope that social sci-3ts will be at least intrigued by my amateur observations and perhaps in-*íd* to more properly study MUDs and their players. In particular, as MUDs >me more widespread, ever more people are likely to be susceptible to the of addiction I discuss; we must, as a society, begin to wrestle with the social ethical issues brought out by such cases....

Pierre Lévy

36» "The Art and Architecture oF Cyberspace," *Collective Intelligence* (1994)

Fierre Lévy. Photo by Darcia Labrosse.
Courtesy of Fierre Lévy.

"Rather than distribute a message to recipients who are outside the process of creation and invited to give meaning to a work ofart belatedly, the artist now attempts to construct an environment, a system of communication and production, a collective event that implies its recipients, transforms interpreters into actors, enables interpretation to enter the loop with collective action."

media theonst and phllosopher Fierre Lévy brings *a* sociological tive to the art and architecture of cyberspace and the emerging study of jlture. His books, *Collective Intelligence: Mankind's Emerging World in Cyberspace* and *Becoming Virtual: ReaHtyinthe Digital Age* (1997), have helped shape the about the aesthetic and social implications of multimedia, ¡nfluencing tand theorists alike. A counterpoint to the dystoplc visión of Burroughs and Lévy points to a digitally conceived utopian universe, a virtual world in i vast repositories of ¡nformation, decentralized authorship, mutable iden-I telematic interaction form an "endless horizon" of evolving forms of art lunication.

identifies an active role for the recipient of the artwork ¡n tándem with tic dissolution of authorial control on the part of its creator. For Lévy, becoming a dynamic, fluid, changing environment, a "deterritorialized : plañe" in which "artist" and "recipient" unite ¡n a consensual interplay formation, execution, and interpretation of art. This shift marks a final from the notion of art as a sacred, discrete object, as indicated by the di-icd authority of the artist's signature, an indelible aspect of art since its be-gs. In its place, he views the digital médium as a continuous and lorative work-in-progress.

ccording to Lévy, the break from traditional notions of authorship ¡s lead-toward cultural transformation. He envisions a collective society linked by riic networks, with citizens actively engaged in the "continuous invention i languages and signs of a community." Rather than approach the Internet, I reality, video games, and emerging media as disparate subjects, Lévy iden-; similarities between their narrative approaches, and treats them as a uni-?ment toward a global culture. Lévy furthers the case made by Douglas irt, and proposes that multimedia is a catalyst for social evolution. It ¡s, "the architecture of the future"—or the language of the new era. »

íerspace under construction

imications networks and digital memorias will soon incorpórate nearly all of representation and messages in circulation. At this point I would like to fcider the significance of the risks involved in developing these networks. Pol-and aesthetics coníront one another within the unbounded construction of cyberspace. The perspective of collective intelligence is only one possible

approach, however. Cyberspace might also presage, or even incarnate, the terri fying, often inhuman future revealed to us by science fiction: the cataloging of th individual, the processing of delocalized data, the anonymous exercise of powei implacable techno-financial empires, social implosión, the annihilation of mera ory, real-time warfare among maddened and out-of-control clones. Nevertht less, a virtual world of collective intelligence could just as easily be as replel with culture, beauty, intellect, and knowledge as a Greek temple, a Gothic cath< dral, a Florentine palazzo, the *Encydopédie* of Diderot and d'Alembert, or th Constitution of the United States. A site that harbors unimagined language galaj íes, enables unknown social temporalities to blossom, reinvents the social boní perfects democracy, and forges unknown paths of knowledge among men. But t do so we must fully inhábil this site; it must be designated, recognized as a | tendal for beauty, thought, and new forms of social regulation. I would like to en this first part of the book with a discussion of the aesthetic dimensión associate with engineering the social bond, which primarily focuses on the design of q berspace and the use of creative play within this new environment of commun cation and thought.

Cyberspace. Of American origin, the word was used for the first time in 198 by the science-fiction writer William Gibson in his novel *Neuromancer.*[}] Cybe space designates the universe of digital networks as a world of interaction and ai venture, the site of global conflicts, a new economic and cultural frontier. The currenüy exists in the world a wide array of literary, musical, artistic, even poli ical cultures, all claiming the tille of "cyberculture." Bul cyberspace refers less i the new media of information Iransmission ihan lo original modes of crealion ai navigalion within knowledge, and the social relations they bring aboul. The would include, in no particular order: hyptertext, ihe World Wide Web, inte active multimedia, video games, simulations, virlual realily, lelepresence, *a.\i* menled realily (whereby our physical environment is enhanced with networks sensors and intelligent modules), groupware (for collaborative activities), neur mimelic programs, artificial life, experl syslems, ele. All of these lools are coi bined in exploiling ihe molecular characler of digilized informalion. Vanen hybrids of ihe above lechnologies and convenlional media (telephone, film, leí visión, books, newspapers, museums) will come inlo existence in the near futuí Cyberspace constitutes a vasl, unlimiled field, slill parlially indelerminale, whii shouldn't be reduced to only one of its many componenls. It is designed to i terconnect and provide an interface for the various methods of creation, recor ing, communication, and simulalion.

While ihe Irue "greal works" remain lo be accomplished wilhin ihe univeí

af digital information and at the new sites for the emergence of collective intelli-^ence, we continué to encumber the landscape with cement, glass, and steel. We liave built pyramids when we are in the process of again becoming nomads, when an architecture for a new exodus is needed. In the silence of thought, we will travel the digital avenues of cyberspace, inhábil weightless mansions that will now constitute our subjectivity. Cyberspace: urban nomad, software engi-neering, the liquid architecture of the knowledge space. It brings with it methods of collective perception, feeling, remembrance, working, playing, and being. It is in interior architecture, an unfinished system of intelligence hardware, a gyrat-ing city with its rooftops of signs. The development of cyberspace, the quintes-sential médium of communication and thought, is one of the principal aesthetic ind political challenges of the coming century.

Digital interactive multimedia, for example, explicitly poses the question of iie end of logocentrism, the destitution of the supremacy of discourse over other nodes of communication. It is likely that human language appeared simultane)usly in several forms: oral, gestural, musical, iconic, plástic, each individual exjression activating a given región of a semiotic continuum, bouncing back and brth from one language to another, from one meaning to another, following the •hizomes of signification, increasing the powers of mind as it traversed the body md its affects. The systems of domination founded on writing have isolated lan;uage, established its mastery over a semiotic territory that has been cut up, >arceled out, and judged in terms of a sovereign *logas.* The appearance of hy>ermedia, however, sketches an interesting possibility (among others that are ess interesting): A resurgence that lies well within the path opened by writing ills short of a triumphant logocentrism and moves toward the rediscovery of a leterritorialized semiotic plane. But such a resurgence will be enriched with the iowers of the text; it will be based on instruments that were unknown during the 'aleolithic and are capable of bringing signs to life. Rather than limiting ourselves d the facile opposition between reasonable text and fascinating image, shouldn't *r&* attempt to explore the richer, subtler, more refined possibilities of thought and xpression created by virtual worlds, multimodal simulations, dynamic writing icdia?

In evaluating these new technologies, should we limit ourselves to the conspts of the information highway, telecommuting, interactive CDs, and virtual reity gaming that are presented for public consumption by the media? In doing) we lose sight of the continuity between these spectacular phenomena and the ivisible, day-to-day use of existing intellectual technologies. When such new ichnologies are presented as unrelated phenomena, as objects fallen from the sky, we lose sight of the open and dynamic system they form, their interconnec-tion in cyberspace, their contentious insertion in ongoing cultural processes. ^ e remain blind to the different possibilities they offer to human becoming, possibilities whose full scope is rarely perceived and which should be the subject o: deliberation, choice, and judgments of taste, rather than the fiefdom of technica-specialists. Even in terms of the apparatus of communication and thought, we are neglecting the dimensión of interiority and collective subjectivity, ethics, and sensibility that even the most seemingly technical decisions imply.

from design to implementation

With respect to its relationship to future projects, cyberspace will assume th; form of a cultural attractor, which we can summarize as follows.

3. Called, controlled, dismissed, distanced, combined, etc., no matterthey are orchestrated, messages, regardless of type, will now revolve arouncthe individual receiver (the opposite of the situation represented by **the**mass media).
4. The distinctions between authors and readers, producers and spectator?-creators and interpreters, will blend to form a reading-writing continuur.which will extend from machine and network designers to the ultimate **re-**cipient, each helping to sustain the activity of the others (dissoludon athe signature).
3 . The distincüon between the message and the work of art, envisaged as a nt-croterritory attributed to an author, is fading. Representation is now sur-ject to sampling, mixing, and reuse. Depending on the emerging pragman : -of creation and communication, a nomadic distribution of information w_ fluctuate around an immense deterritorialized semiotic plañe. It is theretc *r*-natural that creative effort be shifted from the message itself to the mear^-processes, languages, dynamic architectures, and environments used for .1 implementation.

Some of the questions that artists have been asking since the end of the ni:.: teenth century will thus become more urgent with the emergence of cyberspact-These questions are directly concerned with the question of the frame: the ***fm-***its of a work, its exhibition, reception, reproduction, distribution, interpretatk». and the various forms of separation they imply. Under the present circumstanctt. however, no form of closure will be able to contain deterritorialization *in oremis*—a leap into a new space will be required. Mutation will occur in a so:iotechnical environment in which works of art proliferate and are distributed. fet, is it reasonable to even speak of a work of art in the context of cyberspace? For the past several centuries in the West, artistic phenomena have been preented roughly as follows: a person (artist) signs an object or individual message the work), which other persons (recipients, the public, critics) perceive, appreiate, read, interpret, evalúate. Regardless of the function of the work (religious, ecorative, subversive, etc.) or its capacity to transcend function in search of the ore of enigma and emotion that inhabits us, it is inscribed within a conventional attern of communication. Transmitter and receiver are clearly differentiated id their roles uniquely assigned. The emerging technocultural environment, Dwever, will encourage the development of new kinds of art, ignoring the sepation between transmission and reception, composition and interpretation. evertheless, the ongoing mutation créales a realm of the possible that may never realized or only incompletely. Our primary goal should be to prevent closure >m occurring too quickly, before the possible has an opportunity to deploy the riety of its richness. With the disappearance of a traditional public, this new m of art will experiment with different modalities of communication and cre-

Rather than distribute a message to recipients who are outside the process of ation and invited to give meaning to a work of art belatedly, the artist now atipts to construct an environment, a system of communication and production, jllective event that implies its recipients, transforms interpreters into actors, bles interpretation to enter the loop with collective action. Clearly the "open •k" prefigures such an arrangement. But it remains trapped in the hermeneujaradigm. The recipients of the open work are invited to fill in the blanks, ose among possible meanings, confront the divergences among their interations. In all cases it involves the magnification and exploration of the posities of an unfinished monument, a succession of initials in a guest book ed by the artist. But the art of implicaüon doesn't constitute a work of art at ven one that is open or indefinite. It brings forth a process, attempts to open eer to autonomous lives, provides an introduction to the growth and habin of a world. It places us within a creative cycle, a living environment of h we are always already the coauthors. Work in progress? The accent has shifted írom work to progress. Its embodiment is manifested in moments, s, collective dynamics, but no longer in individuáis. It is an art without a sig- e.

he classic work of art is a gamble. The more it transmutes the language on

which it rides, be it musical, plástic, verbal, or other, the more its author run¡ risk of incomprehension and obscurity. But the larger the stake—the degr< change or fusión to which its language is subject—the greater the potential j the creation of an event in the history of a culture. Yet this game of language. wager on incomprehension and recognition, is not restricted to artists al Each of us in our own way, as soon as we express ourselves, produces, re duces, and alters language. From singular utterances to creative listening. guages emerge and drift along the stream of communication, borne by thous; of voices that cali and respond to one another, take risks, provoke and deo hurling words, expressions, and new accents across the abyss of non-sensí this way an arüst can appropriate an expression inherited from earlier general and help it evolve. This is one of the primary social functions of art: participz in the continuous invention of the languages and signs of a community. Bu creator of language is always a community.

Radicalizing the classical function of the work of art, the art of implication ates tensión and provides us with sign machines that will enable us to inveni languages. Critics may claim that we have been producing languages fon True, but without our awareness. To avoid trembling in the face of our owi dacity, to mask the void beneath our feet, or simply because this activity has 1 so slow that it has become invisible, or because it has had to encompass m* of people in constant motion, we have preferred the illusion of foundation. the price of this illusion has been our sense of defeat. Powerless before the guage of the absolute, overeóme by the transcendence of the *lagos,* exhaustí the presence of the artist's inspired effusions, castigated and corrected, bea the weight of forgotten tongues, we falter beneath the exteriority of langt The art of implication, which can only give some idea of its true scope in cy space, by organizing cyberspace, is an art of therapy. It encourages us to ex] ment with the collective invention of a language that recognizes itself as such. in so doing, it points to the very essence of artistic creation.

Having stepped out of the bath of life, far removed from their áreas of c petence, isolated from one another, individuáis finally "have nothing to say." difficulty lies in trying to comprehend them—in both the emotional and ti logical sense—as a group, in engaging them in an adventure in which they *e* imagining, exploring, and constructing sentient environments together. Ev live and real-time technologies play a role in this undertaking, the time ex] enced by the imagining community overflows the staccato, accelerated, qi punctual temporality of "interactivity." The inadequacy of the immediat amnesiac channel hopping, no longer leads to lengthy sequences of interp

tion, the infinite patience of tradition, which encompasses in a single sweep the ages of the living and the dead, and employs the quick currents of the present to erect a wall against time. In much the same way as madrepores erect coral reefs, commentary, strata upon strata, is always transformed into a subject for com-mentary. The rhythm of the imagining community resembles a very slow dance, a slow-motion choreography, in which gestures are slowly adjusted and respond with infinite precaution, in which the dancers gradually discover the secret *tempi* that will enable them to shift in and out of phase. Each learns from the others how to make their entrance in stately, slow, and complicated synchrony. Time in the intelligent community spreads itself out, blends with itself, and calmly gathers it-self together like the constantly renewed outline of the delta of a great river. The imagining collective comes into being so that it may take the time to invent the ceremony by which it is introduced, which is at the same time a celebration of ori-gin and origin itself, still undetermined.

Employing all the resources of cyberspace, the art of implication reveáis the priority of music. But how can a symphony be created from the buzz of voices? Lacking a score, how can we progress from the murmur of the crowd to a cho-rus? The collective intellect continuously questions the social contract, maintains the group in a nascent state. Paradoxically, this requires time: the time to make sure people are involved, time to forge bonds, to bring objects into being, shared landscapes ... the time to return. From the point of view of a watch or a calendar, the temporality of the imagining collective might seem displaced in time, in-terrupted, fragmented. But everything occurs within the obscure, invisible folds of the collective itself: the melodic line, the emotional tonality, the hidden inter-vals, the correspondences, the continuity that it weaves within the hearts of the individuáis who compose it.

for an architecture df deterritorialization

Fhe artists who explore such alternatives may be the pathfmders of the new ar-:hitecture of cyberspace, which will undoubtedly become one of the major arts)f the twenty-first century. The new architects could just as easily be engineers, ictwork or interface designers, software programmers, international standards irganizations, information lawyers, etc., as individuáis with a background in tra-litional forms of art. In this field the most obviously "technical" choices will

tiave considerable política!, economic, and cultural impact. We know that tradidonal architects and urban planners have helped produce our material, practical. and even symbolic environment. In the same way, the sponsors, designers, and engineers of cyberspace will help produce the environraents of thought (sign systems, intellectual technologies), action (telecommuting, remote operation). and communication (access rights, rate policies) that will, to a large extent, struc-ture social and cultural developments.

To guide the construction of cyberspace, to help us choose among the different possible orientations or even imagine new ones, some criteria of ethical and political selection are needed, an organizing visión. Means that contribute to the production of a collective intelligence or imagination should be encouraged. In keeping with this general principie, I would suggest that we concéntrate on the following:

45. Instruments that promote the development of the social bond throughapprenticeship and the exchange of knowledge
46. Methods of communication that are predisposed to acknowledge, intégrate, and restore diversity rather than simply reproduce traditional media-driven forms of distribution
47. Systems that promote the emergence of autonomous beings, regardless ofthe nature of the system (pedagogical, artistic, etc.) or the beings involved(individuáis, groups, works of art, artificial creatures)
48. Semiotic engineering that will enable us to exploit and enhance, for thebenefit of the greatest number, the veins of data, the capital of skills, andsymbolic power accumulated by humanity

In terms of the creation and management of signs, the transmission of knowledge, the development of living and thinking spaces, the best propaedeutic is ob-viously supplied by literature, art, philosophy, and high culture in general. Barbarism is born of separation. Contrary to what they may think, technicians I have a great deal to learn from humanists in this área. Likewise, those in the hu-1 manities must make an effort to employ the new tools, since they redefine work of intelligence and sensation. Lacking such interaction, we will ultimat produce nothing more than a meaningless technology and a dead culture.

I am making a case here for an architecture without foundations, similar to: boat, with its system of practical oceanography and navigation. Not some be symbolic structure, analogous to a static image of the body or mind, the refle tion of a stable world. On the contrary, the architecture of the exodus will give n~ > nomadic cosmos that travels the universe of expanding signs; it will bring >ut endless metamorphoses of bodies; within the fissure of flesh and time, it [dispatch its fleets toward the inviolate archipelagos of memory. Far from en-dering a theater of representation, the architecture of the future will assemble s of icons to help us cross the seas of chaos. Attentive to the voice of the col-ive brain, translating the thought of plurality, it will erect sonorous palaces, ;s of voices and chants, instantaneous, luminous, and dancing like flames.

—translated by robert bononno

37» "Agency," tfam/ef on *the Holodeck(W37]*

Myst. *Courtesy of Cyan Worlds, Inc.*

"In games, therefore, we have a chance to enact our most basic relationship to the world—our desire to prevail over adversity, to survive our inevitable defeats, to shape our environment, to master complexity, and to make our lives fit together like the pieces of a jigsaw puzzle."

Janet H. Murray isoneof the leading scholars in interactive game design. Au-' of the influentiai book, *Hamlet on the Holodeck: The Future of Narrative in Cyberspace,* work has been widely embraced as *a* roadmap by artists and designers shap-the future of digital narrative. In her writing Murray identifies the formal par-¡ms used by leading game developers; from these observations she synthesizes iherent approach to computer-based storytelling. Her critical analyses of in-ictive narrative, role-playing games, interactive televisión, and large-scale timedia information spaces have shed light on design strategies and dra-,ic methodologies for new media artists, designers, and educators. Of central ¡mportance to Murray is the concept of "agency," which she debes as "the satisfying power to take meaningful action and see the results of decisions and choices." In this chapter from her book she discusses the game nents that contribute to this empowerment of the participant—spatial navi-on, labyrinthine puzzles, contests, and extensibility. She also reviews such key gational structures as the "soivable maze/'the "tangled rhizome/'and the irney story." Murray emphasizes that, regardless of form, for an interactive ative to besuccessful it mustengagethefull participaron of the audience— 3 use her preferred term, the "interactor."

Vlurray notes that interactive multimedia has an architectonic aspect that htens agency by inviting the interactor to navigate ¡ts space. But while the icipant can make ¡mportant choices about the direction of an interactive nar-'e, the artist remains the "procedural author," creating "not just a series of es but a world of narrative possibilities."The exploration of a world, and the unter between the consciousness of the interactor and the artist who designs world, is what leads to, in Murray's words, "the pleasures of agency." »

6 more realizad the immersive environment, the more active we want to be n it. When the things we do bring tangible results, we experience a delight ictronic environments—the sense of agency. Agency is the satisfying power :e meaningful action and see the results of our decisions and choices. We ex-to feel agency on the computer when we double-click on a file and see it before us or when we enter numbers in a spreadsheet and see the totals ust. However, we do not usually expect to experience agency within a nar-; environment. ven in the rare circumstances when we are invited to particípate in a tradi- narrative form, our participation is circumscribed in a way that generally

limits our sense of agency. For instance, if the audience at a performance of *P<Pan* decided that Tinkerbell is a pest and refused to clap her back to life, the jwould come to a halt. The participatory dinner theater plays that simúlate an 1ian wedding or an Irish wake or a Jewish funeral encourage audience partidtion by keeping the plot to a minimal level and the dialogue with the audiencsocial formulas appropriate to distant friends of the family. When the groorsuch a play leans down to kiss me as a guest at his wedding, I can congratuhim and warn him about staying away from his ex-girlfriend now that he is nried, but I cannot really influence his behavior. When audience members arecluded in the story, they serve only as the butt of ajoke. They may be accuseadultery by the priest or shot by a mañoso relative. The slender story is desigto unfold in the same way no matter what individual audience members majto join the fun

Because of the vague and pervasive use of the term *interactivity,* the pleaj of agency in electronic environments is often confused with the mere abilit move a joystick or click on a mouse. But activity alone is not agency. Foi stance, in a tabletop game of chance, players may be kept very busy spim dials, moving game pieces, and exchanging money, but they may not have truc agency. The players' actions have effect, but the actions are not chosen the effects are not related to the players' intentions. Although gamemakers so times mistakenly focus on the number of interactions per minute, this numb a poor indicator of the pleasure of agency afforded by a game. Some games, chess, can have relatively few or infrequent actions but a high degree of age since the actions are highly autonomous, selected from a large range of poss choices, and wholly determine the course of the game.

Agency, then, goes beyond both participation and activity. As an aestl pleasure, as an experience to be savored for its own sake, it is offered to a lira degree in traditional art forms but is more commonly available in the structi activities we cali games. Therefore, when we move narrative to the compute] move it to a realm already shaped by the structures of games. Can we imagi compelling narrative literature that builds on these game structures without b diminished by them? Or are we merely talking about an expensive way to rev *Hamkt* for the pinball machine?

the pleasures of navigation

One form of agency not dependent on game structure yet characteristic of i tal environments is spatial navigation. The ability to move through virtual I ipes can be pleasurable in itself, independent of the content of the spaces. A ;nd of mine whose son is an avid Ninlendo player complains that when he tries t the games he is annoyed at having to be fighting all the time, since the com-t is an unwelcome distraction from the pleasure of moving around the unfold-; spaces of the ma/e. For my friend, videogames are about exploring an initely expandable space. Similarly, new explorers of the World Wide Web d themselves entranced with the ability to leap around the world, following ks from one home page or Web site to the next mostly for the pleasure of the >eated arrivals. The navigational pleasures are richly exploited by the many ms of labyrinths, from Zor/fc-like dungeons to informational webs, that fill cy-•space. All of them allow us to experience pleasures specific to intentional dgation: orienting ourselves by landmarks, mapping a space mentally to match • experience, and admiring the juxtapositions and changes in perspective that ive from moving through an intricate environment.

This participatory pleasure is not unlike the enjoyment people find in the or-dzed sport of "orienteering," where players follow a series of geographical es across a large and complex terrain, such as a portion of the Maine woods lowntown Boston. Construing space and moving through it in an exploratory ' (when done for its own sake and not in order to find the dentist's office or right airport gate) is a satisfying activity regardless of whether the space is real irtual. Electronic environments offer the pleasure of orienteering in two very srent configurations, each of which carries its own narrative power: the solv-; maze and the tangled rhizome.

ie story in the maze

t-like puzzle dungeons and maze-based combat videogames derive from a >ic narrative of adventure whose roots are in antiquity. It was Daedalus who t King Minos of Crete a labyrinth to contain the deadly Minotaur. The hor-: beast required the yearly sacrifice of Athenian youths and maidens, whom voured, until the hero Theseus arrived to slay it. In the story, Ariadne, the fhter of the king, fell in love with Theseus and gave him a sword to kill the t and a thread to find his way out again. Minos's maze was therefore a fright-g place, full of danger and bafflement, but successful navigation of it led to : rewards.

The adventure maze embodies a classic fairy-tale narrative of danger and sal-n. Its lasting appeal as both a story and a game pattern derives from the ling of a cognitive problem (finding the path) with an emotionally symbolic pattern (facing what is frightening and unknown). The maze story celébrales combination of intelligence and courage, and it depicts romantic love as the < ment that provides the hope that brings the hero into the confrontation and b¡ out again to safety. Like all fairy tales, the maze adventure is a story about survi The maze is a road map for telling this story.

As a format for electronic narrative, the maze is a more active versión of i immersive visit. Maze-based stories take away the moving platform and n the passively observant visitor into a protagonist who must find his or her o way through the fun house. A typical maze-based puzzle game sends you. I player, through a multitiered space vaguely resembling an *Arabian Nig* palace. You opérate an avalar who walks through the palace rooms, whose ti floors and ornately decorated corners often hide treasures that are tricky to p ceive. The palace is full of informants, who speak in text bubbles and whom *y* reply to from menus, and you must negotiate with them carefully, offering thi icons representing money or other valuables. A mysterious peddler on one the lower levéis holds a talismán needed to get into the highest chamber. "V must have it with you while you stand on a special spot that is hidden in the p terning of the floor. If you forget to get it, you must retrace your steps throu many perils. The game is like a treasure hunt in which a chain of discoveries a as a kind of Ariadne's thread to lead you through the maze to the treasure at I centén

This kind of narrative structure need not be limited to such simplistic c< tent or to an explicitly mazelike interface. In the right hands a maze story coi be a melodramatic adventure with complex social subtexts. For instance, instí of a fairy-tale palace it could be set in a Kafkaesque city where the secret pol are rounding up and deporting citizens with the wrong kind of papers. The p tagonist's role would be to save them, a task that would require navigad through the corridors of power and through underground hiding places, elal rately conducted negotiations, clever manipulation of bureaucrats, and sp second timing. The characters in the menacing world could be subtly portrayt in either graphics with text bubbles or in video segments. Saving people mij involve horrifying choices, perhaps implicating the protagonist in the corrupri of the violent world. The maze could be composed not only of spatial twists I of moral and psychological choices.Just as it hard to see where a tangle of viro corridors is leading, so too would it be hard to foresee the consequences of yo actions and to determine what to valué and whom to trust. Just as Kafka used I conventions of the fable to convey the profound depersonalization of modern 1 and Art Spiegelman used the format of the comic book to tell the story of his

.er's Holocaust experiences, a digital artist might use the structure of the ad-:nture maze to embody a moral Índividual's confrontation with state-sanctioned olence.

Whether an adventure maze is simple or complex, it is particularly suited to e digital environment because the story is tied to the navigation of space. As I ove forward, I feel a sense of powerfulness, of significan! action, that is tied to *y* pleasure in the unfolding story. In an adventure game this pleasure also feels :e winning. But in a narrative experience not structured as a win-lose contest e movement forward has the feeling of enacting a meaningful experience both nsciously chosen and surprising. However, there is a drawback to the maze ori-tation: it moves the interactor toward a single solution, toward finding the one ly out. The desire for agency in digital environments makes us impatient when r options are so limited. We want an open road with wide latitude to explore d more than one way to get somewhere. We want the "pullulating" web that rges described, constantly bifurcating, with every branch deeply explorable.

-\PTURE OF THE ÜHIZOME

e second kind of digital labyrinth, which has arisen from the academic liter-community, is the postmodern hypertext narrative. Full of wordplay and insrminate events, these labyrinths derive not from Greek rationalism but from tstructuralist líterary theory and are unheroic and solutionless. Like a set of ;x cards that have been scattered on the floor and then connected with mul-2 segments of tangled twine, they offer no end point and no way out. Their hetic visión is often identified with philosopher Gilíes Deleuze's "rhizome," ber root system in which any point may be connected to any other point.[1] íuze used the rhizome root system as a model of connectivity in systems of s; critics have applied this notion to allusive text systems that are not linear a book but boundaryless and without closure. Stuart Moulthrop, a theorist electronic fiction writer, states it this way:

> leen from the viewpoint of textual theory, hypertext systems appear as the prac-ícal implementation of a conceptual movement that... rejects authoritarian, "lo-ocentric" [i.e., truth-affirming] hierarchies of language, whose modes of peration are linear and deductive, and seeks instead systems ofdiscourse that dmit a plurality of meanings where the operative modes are hypothesis and in-irpretive play.[2]

The postmodern hypertext tradition celébrales the indeterminate text as a li eration from the tyranny of the author and an affirmation of the reader's freedc of interpretation. But the navigational software designed specifically for this pu pose and celebrated by many proponents of literary hypertext is anything but en powering to the reader, even in comparison to the earliest Web browsers.[3] F< instance, it offers the navigating reader no way to mark links as having been ; ready taken, and no way to mark a lexia so it can be easilyjumped back to. Mar of the stories written in this framework do not even mark which words are ha links within the lexia text. Instead, the reader has to click on a pop-up display cryptic link ñames. Moulthrop's own *Victory Carden,* which is perhaps the *mot* coherently structured literary hypertext, contains a clever overview map of th major story clusters, which are arranged like a Borgesian garden labyrinth. B readers cannot easily return to the overview in order to get a sense of where th are or how much is left to read. In trying to créate texts that do not "privilege any one order of reading or interpretive framework, the postmodernists are pn ileging confusión itself. The indeterminate structure of these hypertexts fru trates our desire for narrational agency, for using the act of navigation to unfo a story that flows from our own meaningful choices.

But the unsolvable maze does hold promise as an expressive structure. WalkJ ing through a rhizome one enacts a story of wandering, of being enticed in conflicting directions, of remaining always open to surprise, of feeling helpless td orient oneself or to find an exit, but the story is also oddly reassuring. In the rhizome, one is constantly threatened but also continuously enclosed. The fact that the plot will not resolve means that no irreparable loss will be suffered. The narrator of Michaeljoyce's *Afternoon* will not have to confront the fact of the morn-i ing's fatal accident so long as the afternoon's evasive wanderings continué, andj the reader of *Victory Garden* does not have to accept the death of an appealing character so long as there are múltiple paths to explore, including some that lead to altérnate realities in which she comes back home from the war. In both stories the reader is protected from feeling the irreversibility of death by the fact that the stories do not have to end there.

The boundlessness of the rhizome experience is crucial to its comforting side. In this it is as much of a game as the adventure maze. In fact, it reminds me of a particular game my son William invented at about age five. At his own initiative he one day drew a large game board, assembled dice and playing pieces, and invited his father to join him in an inventively improvised game with ever-changing and ever more elabórate rules. After two hours of this surreal activity. my husband became restless and began asking every five minutes or so if the ime was almost oven William responded by calmly walking into the kitchen, here I was sitting, and asking me to write his father the following note:

DEAR DAD—THIS GAME WILL NEVER END. WILLIAM

he rhizome has the same message. As we navigate its tangled, anxiety-laden iths, enclosed within its shape-fitting borders, we are both the exasperated par-it longing for closure and separation and the enthralled child, lingering forever an unfolding process that is deeply comforting because it can never end.

riviNG shape to anxiety

Dth the overdetermined form of the single-path maze adventure and the under-itermined form of rhizome fiction work against the interactor's pleasure in navi-.tion. The potential of the labyrinth as a participatory narrative form would em to lie somewhere between the two, in stories that are goal driven enough to dde navigation but open-ended enough to allow free exploration and that dis-ay a satisfying dramatic structure no matter how the interactor chooses to tra-rse the space.

The key to creating an expressive fictional labyrinth is arousing and regulat-*t* the anxiety intrinsic to the form by harnessing it to the act of navigation. Sus-nse, fear of abandonment, fear of lurking attackers, and fear of loss of self in the .diíferentiated mass are part of the emotional landscape of the shimmering :b. Moving through the space can therefore feel like an enactment of courage d perseverance, like Gary Cooper's striding through the town in *High Noon.* >mputer gamers often experience shivers of physical fear as they approach an opened door in a text-based or graphics-based labyrinth. The drama of sus-nseíul approach does not have to be tied to combat or to jack-in-the-box ef-ts. It can also have the feeling of a determination to face the truth, to stare •ectly at the threatening beast. It can be experienced by the navigating .der/viewer as well as by the player/protagonist.

One such use of the labyrinth as a means of evoking and controlling terror is :ory formal increasingly used by my fiction students, a story I have come to cali "violence hub." Writers will place an account of a violent incident, often a real invented newspaper article, at the center of a web of narratives that explore it m múltiple points of view. A helicopter accident near MIT, a robbery in a ivenience store, a canoeing fatality—these are all examples of an act of sudden lence that have served as the center of such a story web. The incident account itself is usually bare but evocative. People have died in violent but su prising circumstances, we are told. The incident happened at a particular pla< and time involving a particular group of people. The ñames in the account or i a diagram of the site of the accident lead outward with hot links to the satellite fii that tell us how the incident appeared to the various people involved—the p petrator, the witnesses, the rescuers, the victims, the survivors.

The proliferation of interconnected files is an attempt to answer the pereí nial and ultimately unanswerable question of why this incident happened. For ii stance, one convenience store robbery labyrinth follows the robber, the clerk. ti owner, and the cop (who shoots the robber) back through the events leading u to the shootout and forward again into the moment of violence.[4] Reading it m feel sympathy with all of them, and we can see how they appeared to one anothe A web story of a teenager who drowned on a white-water canoeing trip descrita the traumatic experience from the points of view of the friends he was traveliu with, the operators of the canoeing company, the emergency medies, and ti family members receiving the dreadful phone cali. These violence-hub stories d not have a single solution like the adventure maze or a refusal of resolution lil the postmodern stories; instead, they combine a clear sense of story structuí with a multiplicity of meaningful plots. The navigation of the labyrinth is like pa< ing the floor; a physical manifestation of the effort to come to terms with ti trauma, it represents the mind's repeated efforts to keep returning to a shockiil event in an effort to absorb it and, finally, get past it. The retracing of the situs tion from different perspectives leads to a continual deepening in the reader's ui derstanding of what has happened, a deepening that can bring a sense < resolution but one that allows for the complexity of the situation and that leaví the moment of shock unchanged and still central.

A linear story, no matter how complex, moves toward a single encompassin versión of a complex human event. Even those multiform stories that offer mu tiple retellings of the same event often resolve into a single "true" versión—th viewpoint of the uninvolved eyewitness or the actual reality the protagonisl wind up in after the altérnate realities have collapsed. A linear story has to en in some one place: the last shot of a movie is never a split screen. But a mult threaded story can offer many voices at once without giving any one of them th last word. This is a reassuring formal for encountering a traumatic event becaua it allows plenty of room for conflicting emotions. It lets us disperse complex. ir tense reacü'ons into many derivative streams so that we do not have to feel the fu flood of sorrow all at once. The multithreaded web story achieves coherent dn matic form by shaping our terror into a pattern of exploration and discovery.

phejourney story and the pleasure >f problem solving

'he navigational space of the computer also makes it particularly suitable for >urney stories, which are related to mazes but ofler additional opportunities for iercising agency. Journey stories date back to oral storytelling, from the fairy-tale onvention of setting out from home to find one's fortune to the voyages of Idysseus and Sinbad. It is a universal archetype recognizable across all the vari-ions of culture, author, and médium. After the invention of the printing press, le journey story was reinvented as the picaresque novel, exemplified by *Don 'uixote, Molí Flanders, Tom Jones, Huckleberry Finn,* and *Catcher in the Rye.* fith the invention of the movie camera, the journey story was again revived, and s variations include everything from the comic (e.g., Buster Keaton's *The Gen-•at)* to the cowboy melodrama *(e.g.,Stagecoach, The Searchers)* and the feminist iddy film *(Thelma andLouisé).* When televisión carne along, journey stories *Vagón Train, Route* 66, *The Fugitive,* and, of course, *Star Trek)* were among the ost successful series.

Moving thejourney story from the fairy tale to the novel meant moving it from iymbolic realm of universal actors (a king, a wicked stepmother) to a particuized social world and a particular time and place. In the novel the cruel things it happen to the hero are often treated as instances of a specific social injustice, e the English Poor Laws, rather than as the work of a generic antagonist like a 5 bad wolf. Moving thejourney to the movies opened up the visual dimensión the archetype. Journey films often emphasize exotic landscapes, foreign cul•es, and the lure of open spaces. Since televisión is best at portraying interior imas and family-size social units,[5] journey stories on TV generally focus on a :cession of small commumties or even replace the hero and sidekick with an iré traveling community, as on *Star Trek.* On the computer thejourney story phasizes navigation—the transitions between difieren! places, the arrivals and Dartures—and the how-to's of the hero's repeated escapes from danger.

One of the consistent pleasures of the journey story in every time and every dium is the unfolding of solutions to seemingly impossible situations. We .ch each new situation along the road and wonder how the hero will escape a .ring or a hanging or a forced marriage or jailing. When Odysseus foolishly als himself to be captured by the Cyclops, a huge, one-eyed man-eater, he is preted with a life-and-death riddle. The situation is carefully described so that it seems that he has no chance of getting out. The Cyclops is a brutal and heart less creature who brags that he is unafraid of Zeus and therefore free to do as *ht* picases. Every night two more of Odysseus's men are caten; the survivors knoM they must get out soon or die. They could kill the monster as he sleeps, but tru cave is barred with a stone too heavy for them to move; if they kill him, they wJ never get out again. The Cyclops's routine is unvaried: he goes ofFwith the sheej in the morning, closing the cave behind him, and comes back at night with thi sheep, ready for a dinner of Greek sailors. Then Odysseus (who is narrating th(story) tells us how he solves the problem. He prepares some wine. He prepara a battering ram and gathers a group of strong helpers. He tells the giant his nam< is "Nobody" and gets him very drunk. When the Cyclops falls asleep, Odysseui and his men heat the battering ram in the fire and thrust it into his one terribl< eye. Now the giant is blinded, but how will the Greeks get out? While the Cyclop is raging, Odysseus sepárales the sheep into groups of three and places each a his men under the middle sheep and himself beneath the strongest ram in th< flock. Finally, the Cyclops lets out his sheep, as Odysseus has seen him do everj morning, and out go all the Greeks with them. And when the wounded Cyclopí cries out for help from his neighbors, whom does he say is tormenting himí "Nobody." Odysseus's description is constructed so that we can enjoy each in dividual step and gain increasing pleasure as the overall plan becomes clear. Th< story is as much a riddle as Oedipus's, but the answer to the riddle is not in a sin gle word; it is in a series of beautifully orchestrated steps, an elegant algorithm foi defeating giants.

Computer-based journey stories offer a new way of savoring exactly this plea sure, a pleasure that is intensified by uniting the problem solving with the activi process of navigation. On the computer the dramatic situation of capture and es cape can be simulated by keeping the player within a confined space until the so lution to a puzzle is found. These puzzles are most satisfying when the action have a dramatic appropriateness, when they serve as a way of increasing our be lief in the solidity and consistency of the illusory world. For instance, in *Myst* thi wizard's island includes an elevator hidden in a giant tree and operated by ¡ nearby control panel. In addition to solving the puzzle of the panel, the interac tor must move efficiently through the space to get to the elevator at just the righ moment in its descent. The concreteness with which the space is detailed make the sequence feel not like a test of coordination but like a dramatic moment. B; contrast, in the computer game *The Seventh Guest,* the player is asked to cut uj a cake into enough segmenta to match the number of murder victima. The puz zle is a satisfying one, but since there is no one there to eat the cake, the actioi takes us outside the immersive world instead of reinforcing our belief in it.

The most dramatically satisfying puzzles are those that encourage the interior to apply real-world thinking to the virtual world. For instance, a computa-Dnally sophisticated MIT student who is also an expert gamer instanced a irticular dramatic moment from the text-based *Zork* //as among his lifetime fa->rites: The story involves a dragón that is slow to rouse but always lethal if you :rsist in fighting him. Elsewhere in the dungeon is a wall of ice that is impossi-e to pass. What you must do is attack the dragón enough to get his attention— it not so much that he "toasts" you— and then run and head for the wall of ice. he dragón íbllows, sees his reílection in the ice, and thinks it is another dragón. e rears up and breathes fire at his enemy; as he does so, the ice melts, drown-g the dragón and eliminating the obstructing wall.[6] Like Odysseus in the Cy->ps's cave, the player escapes by outsmarting a ferocious monster using only the iterials at hand.

ames into stories

mes seem on the face of it to be very different from stories and to ofíer oppos-
; satisfactions. Stories do not require us to do anything except to pay attention
hey are told.[7] Games always involve some kind of activity and are often focused
the mastery of skills, whether the skill involves chess strategy or joystick twitch-
. Games generally use language only instrumentally ("checkmate," "ball four")
icr than to convey subtleties of description or to communicate complex emo-
is. They ofFer a schematized and purposely reductive visión of the world.
st of all, games are goal directed and structured around turn taking and keep-
score. All of this would seem to have nothing to do with stories.

In fact, narrative satisfaction can be directly opposed to game satisfaction, as
endings of *Myst,* widely hailed as the most artistically successful story puzzle
te early 1990s, make clear. The premise of the *Myst* story is the confinement
vo brothers, Sirrus and Achenar, in magical books that serve as a dungeon.
ough a video window we can see them in their imprisonment and hear them

ng to us in short, staticky segments. Each one warns us about the wickedness
e other and asks us to rescue him. The brothers can be freed only by heroic
rs of problem solving by the player, who must journey to four magical lands
fes and bring back a single page from each of them for either Sirrus or
mar. Each time the player gives one of the brothers a magic page, he re-
ds with a slightly clearer video segment. At the end of the game, when most
e puzzles have been solved, the player has most likely gone to each land
: in order to gather both sets of pages and to hear all of the messages from

both brothers. At this point we are faced with a dramatic choice. The last magí; page will reléase one or the other of them from the book. Which is it to be?

The game is well designed in that all the evidence on which to base a decisión is, as in any good detective story, available to the player. Exploring the var-ious lands reveáis—through accusatory notes, hidden corpses, imperia- furnishings, desolated landscapes, and múltiple instruments of torture and de-struction—the villainy of both brothers. The secret of the game is that although both brothers are evil, their father, Atrus, is alive and—with some more puzzle solving—can be found and rescued. The "winning" ending involves locating tht good wizard Atrus and remembering to bring with you the magical Ítem that wiE free him from captivity. This is a satisfyingly fair yet challenging mystery plot.

Yet surprisingly, the "losing" endings of the game are much more satisfying than the winning ending. In the winning ending one finds a beautifully renderec but dramatically inert video cutout of Atrus superimposed on a backdrop oí very shallow fantasyland. Unlike all the other lands visited during the game, thií one is not really explorable and offers no pleasures of manipulation. It is a deac end. The ending in which you get to the wizard but forget to bring him the mean* of escape is more dramatic, because he gets quite angry at you. But the most dramatically satisfying endings are the near-identical losing branches, which are the result of choosing to rescue either of the evil brothers. The moment you releas* either Achenar or Sirrus from imprisonment, he will mockingly turn on you anc *\ockyou* in the very same dungeon from which he has escaped! The visual efieci is simple but brilliantly effective because it reverses your perspective. Througr--out the game you have peered into each brother's dungeon through a statk-ridden, credit-card-size window embedded within the parchment page of ar enchanted book. The brothers' immobility has been marked by the fact that yot could see little more than their faces. Now you are looking out through a similarH staticky window set into a totally black screen. Through the window you can set the evil brother now exultantly standmg and moving around while looking dowTi at youjust as you had looked down at him. A game that marked a breakthrougi: in ease of navigation appropriately ends by immobilizing the player.

The superiority of the losing endings of *Myst* suggests a basic opposition br tween game form and narrative form. How can we tell significant stories in i form that always has to end happily? How can we impose endings that yic!: complex story satisfactions on a form that is based on win/lose simplicity? Mar. would argüe that computer-based narrative will always be gamelike and that suci satisfactions are therefore inevitable. But when looked at more closely, games and stories are not necessarily opposed.

\mes as symbolic dramas

ame is a kind of abstract storytelling that resembles the world of common exience but compresses it in order to heighten interest.[8] Every game, electronic itherwise, can be experienced as a symbolic drama. Whatever the content of game itself, whatever our role within it, we are always the protagonists of the ibolic action, whose plot runs like one of the following:

3. I encounter a confusing world and figure it out.
4. I encounter a world in pieces and assemble it into a coherent whole.
5. I take a risk and am rewarded for my courage.
6. I encounter a difficult antagonist and triumph over him.
7. I encounter a challenging test of skill or strategy and succeed at it.
8. I start offwith very little of a valuable commodity and end up with a lot ofit (or I start offwith a great deal of a burdensome commodity and get ridof all of it).
9. I am challenged by a world of constant unpredictable emergencies, and Isurvive it.

íven in games in which we are at the mercy of the dice, we are still enacting aningful drama. Playing purely luck-based games is captivating because we lodeling our basic helplessness in the universe, our dependence on unpreble factors, and also our sense of hopefulness. The people who line up at my iborhood convenience store for lottery tickets can be seen either as dupes risk takers engaging in a playful ritual of faith in the benevolence of forces nd their control. In fact, even when we lose, we are still part of the symbolic .a of the game. In that case the plots might go like this:

I fail at an important test and suffer defeat.

I decide to try again and again until I finally succeed.

I decide to win by cheating, that is, by acting outside the rules, because authority is meant to be flouted.

I realize that the world is rigged against me and others like me.
games, therefore, we have a chance to enact our most basic relationship to arld—our desire to prevail over adversity, to survive our inevitable defeats,

to shape our environment, to raaster complexity, and to make our lives fu : gether like the pieces of a jigsaw puzzle. Each move in a game is like a plot even in one of these simple but compelling stories. Like the religious ceremonies ;• passage by which we mark birth, coming of age, marriage, and death, games an ritual actions allowing us to symbolically enact the patterns that give meaning u our lives.

Games can also be read as texts that oífer interpretations of experience. I instance, the board game Monopoly can be read as an interpretation of capiui-ism, an enactment of the allures and disappointments of a zero-sum economv m which one gets rich by impoverishing one's neighbors. Or it can be read as a p;:-terned expression of our knowledge that success in life is always the result of botn planning and chance. When we play Monopoly, we are taking part in a structured drama that offers, in addition to its win/lose ending, moments in which we giv^ expression to our ambition, greed, and benevolence and our tendencies to risks and exploit others. Even a game with no verbal contení, like Tetris wildly popular and poweríully absorbing computer game of the early 1990s. has clear dramatic contení. In Tetris, irregularly shaped objecls keep falling from cha lop of the screen and accumulating at the bottom. The player's goal is to guice each individual piece as it falls and position it so that it will fit together with other pieces and form a uniform row. Every time a complete row forras, it disap-pears. Instead of keeping what you build, as you would in a conventional jigsaw puzzle, in Tetris everything you bring to a shapely conclusión is swept away frora you. This game is a perfect enactment of the overtasked lives of Americana in the 1990s —of the constant bombardment of tasks that demand our attention and tha we must somehow fit into our overcrowded schedules and clear offour desks ii order to make room for the next onslaught.[9]

If the same spatial ideas behind the movement of the colored shapes iu Tetris—relentless activity, misfits and tight couplings, order and chaos, crowdin| and clearing—are represented in a dance, we automatically associate them wid| ordinary human experience, because we see human beings enacting them. *h* the computer game the interactor is the dancer and the game designer is th< choreographer. The screen objects are like a symbolic language for inducing oía activity. So while we experience the game as being about skill acquisition, we an drawn to it by the implicit expressive contení of the dance. Tetris allows us **tt** symbolically experience agency over our lives, It is a kind of rain dance for th» postmodern psyche, meant to allow us to enact control over things outside oui power.

Games are recreational because they offer no immediate benefit to our sur vival. Yet game-playing skills have always been adaptive behaviors. Games tradionally ofFer safe practice in áreas that do have practícal valué; they are rehearsals ir life. Lion cubs roughhouse with one another in order to grow to be predators. small children still play hide-and-seek, a good way of training hunters, and ring-round-a-rosy, a good way of practicing cooperation and coordinated behaviors. older children in our society are understandably drawn to pitting themselves against machines. The violence and simplistic story structure of computer skill ames are therefore a good place to examine the possibilities for building upon le intrinsic symbolic contení of gaming to make more expressive narrative forras.

phe contest story

The most common form of game—the agón, or contest between opponents—is also the earliest form of narrative. This is not surprising since opposition is one of the most pervasive organizing principies of human intelligence and language.[10] ast as we automatically organize the temporal and spatial world into opposing haracteristics (night/day, up/down, right/left), so too do we look at the things lat happen in the world in terms of struggles between opposites (God/Satan, lale/female, Cain/Abel, Jews/Gentiles). The Greek word *agón* refers to both :hletic contests and to dramatic conflicts, reflecting the common origin of games id theater. A simple shoot-'em-up videogame, then, belongs to the extremely road dramatic tradition that gives us both the boxing match and the Elizabethan tvenge play.

Most of the stories currently told on the computer are based on the structure also contest of skill. The interactor is given the role of a fighter or detective of some sort and is pitted against an opponent in a win/lose situation. From their beginnings in the 1970s, computer games have also developed múltiple representations of the opponent, who may be another human player (as in the first videogame, *Pong),* a character embedded in the story (as in *Pacman),* and the programmer or game designer implicit in the game (as in *ZorK).* Contest games have also developed at least three different ways of situating the player: we can watch from a spectator perspective while operating our own avalar character or spaceship (as in *Mortal Kombat);* watch from a situated perspective while operating a character (as in *Rebel Assault,* where we see the vehicle we are operating as if are followingjust behind it with a movie camera); or, most immersively, watch and act from a situated first-person viewpoint, as in *Doom,* where we see the landape of the game and our opponents coming toward us as if we are really present in space. These gaming conventions orient the interactor and make the tion coherent. They are equivalent to a novelist's care with point of view or a| rector's attention to staging.

Fighting games have also developed a sure-ñre way of combining agen with immersion. The most compelling aspect of the fighting game is the tight *y* ceral match between the game controller and the screen action. A palpable cli on the mouse or joystick results in an explosión. It requires very little imagil tive effort to enter such a world because the sense of agency is so direct. T imaginative engagement is even stronger with an arcade-style interface that *í* you sit in a brightly painted model of a spaceship or fire a toy gun. . . .

the interactor as author

One of the key questions that the practice of narrative agency evokes is, To wl degree are we authors of the work we are experiencing? Some have argued (w either elation or horror) that an interactor in a digital story—not just the imp vising MUDder, but even the navigating reader of a postmodern hypertext—is (author of the story. This is a misleading assertion. There is a distinction betwe playing a creative role within an authored environment and having authorship the environment itself. Certainly interactors can créate aspects of digital stor in all these formáis, with ihe grealest degree of creative aulhorship being oí ihose environments that reflect the leasl amount of prescripting. But internen can only act within the possibilities that have been established by the writing a programming. They may build simulated cities, Iry oul combat slralegies, tn a unique path through a labyrinthine web, or even prevent a murder, but urdí ihe imaginary world is nothing more than a costume trunk of empty avatars, of the interaclor's possible performances will have been called inlo being by i originaling author.

Authorship in electronic media is procedural. Procedural authorship me; writing the rules by which the texis appear as well as writing the texis ihe selves. It means writing the rules for the interactor's involvement, ihal is. I condilions under which things will happen in response to ihe parlicipant's ; tions. It means eslablishing the properties of the objecls and polential objects the virtual world and the formulas for how they will reíale lo one another. *1* procedural aulhor créales noljusl a set of scenes bul a world of narralive pos bililies.

In electronic narrative the procedural author is like a choreographer \v supplies the rhythms, the context, and the set of steps that will be performed. The interactor, whether as navigator, protagonist, explorer, or builder, makes use of this repertoire of possible steps and rhythms to improvise a particular dance among the many, many possible dances the author has enabled. We could perhaps say that the interactor is the author of a particular performance within an electronic story system, or the architect of a particular part of the virtual world, but we must distinguish this derivative authorship from the originating authorship of the system itself.

Interestingly enough, the question of authorship in formulaic media is one that students of ancient oral narrative have considered at length. In the 1930s, Greek scholars were distressed when literary analysis revealed that Homer (and other epic preliterate poets) created through a process that involved fitting stock phrases and formulaic narrative units together. Critics at that time resisted the thought that the great artist Homer was not original in the same way that modern print-based writers are expected to be. Now, with the advent of computer-based authorship, we are experiencing the opposite confusión. Contemporary critics are attributing authorship to interactors because they do not understand the procedural basis of electronic composition. The interactor is not the author of the digital narrative, although the interactor can experience one of the most exciting aspects of artistic creation—the thrill of exerting power over enticing and plástic materials. This is not authorship but agency.

Coda

The Language oFthe Future

by LaurieAnderson

Last year, I was on a twin-engine plañe coming from Milwaukee to New York City. Just over La Guardia, one of the engines conked out and we started to drop straight down, flipping over and over. Then the other engine died: and we went completely out of control. New York City started getting taller and taller. A voice carne over the intercom and said:

Our pilot had informed us that we are about to attempt a crash landing.
Picase extinguish all cigarettes.
Place your tray tables in their upright, locked position.
Your Captain says: Picase do not panic.
Your Captain says: Place your head in your hands.
Captain says: Place your head on your knees.
Captain says: Put your hands on your head.
Put your hands on your knees!
(heh-heh)
This is your Captain.
Have you lost your dog?
We are going down. We are all going down together.

As it turned out, we were caught in a downdraft and rammed into a bank. It was, in short, a miracle. But afterwards I was terrified of getting onto planes. The moment I started walking down that aisle, my eyes would clamp shut and I would fall into a deep, impenetrable sleep. You don't want to see this.

You don't want to be
here. Have you lost
your dog?

Finally, I was able to remain conscious, but I always had to go up to the forward cabin and ask the stewardesses if I could sit next to them: "Hi!Uh,mindifIjoinyou?" They were always rather irritated—"Oh, all right (what a baby)"—and I watched their uniforms crack as we made nervous chitchat. Sometimes even this didn't work, and I'd have to find one of the other passengers to talk to. You can spot these people immediately. There's one on every flight. Someone who's really on *your* wavelength.

I was on a flight from L.A. when I spotted one of them, sittíng across the aisle. A girl, about fifteen. And she had this stuffed rabbit set up on her tray table and she kept arranging and rearranging the rabbit and kind of waving to it:
"Hi!" "Hi there!" And I decided: This is the one I want to sit next to. So I sat down and we started to talk and suddenly I realized she was speaking an entirely different language. Computerese. A kind of high-tech lingo. Everything was circuitry, electronics, switching. If she didn't understand something, it just "didn't sean."

We talked mostly about her boyfriend. This guy was never in a bad mood. He was in a bad mode. Modey kind of guy. The romance was apparently kind of rocky and she kept saying: "Man oh man you know like it's so digital!"

She just meant the relationship was on again, off again.
Always two things switching.
Current runs through bodies— And then it doesn't.
It was a language of sounds, of noise, of switching, of

signáis.
It was the language of the rabbit, the caribou, the
penguin, the beaver.
A language of the past.
Current runs through bodies and then it doesn't. On
again. Off again.
Always two things switching. One thing instandy
replaces another. It was
the language of the future.

PUT YOUR KNEES UP TO YOUR CHIN.
HAVE YOU LOST YOUR DOG?
PUT YOUR HANDS OVER YOUR EYES.

JUMP OUT OF THE PLAÑE.
THERE IS NO PILOT. YOU ARE NOT ALONE.
THIS IS THE LANGUAGE OF THE ON-AGAIN
OFF-AGAIN FUTURE.
AND IT IS DIGITAL.

notes and references»

ichard Wagner, "Outlines of the Artwork ofthe Future"

3. The problem of the Theatrical edifice of the Future can in no wise be con-sidered as solved by our modern stage buildings: for they are laid out in ac-cord with traditional laws and canons which have nothing in common withthe requirements of puré Art. Where speculation for gain, on the one side,joins forces with luxurious ostentation on the other, the absolute interests of Art must be cryingly affected; and thus no architect in the world will beable to raise our stratified and fenced-off auditoria—dictated by the par-celling of our public into the most diverse categories of class and civil station—to conformity with any law of beauty. If one ¡magines oneself, for amoment, within the walls of the common Theatre of the Future, one willrecognise with little trouble, that an undreamt width of field lies thereinopen for invention. — R. wagner.

4. It can scarcely be indifferent to the modern landscape-painter to observeby how few his work is really understood to-day, and with what blear-eyed stupidity his nature-paintings are devoured by the Philistine world thatpays for them; how the so-called "charming prospect" is purchased to as-suage the idle, unintelligent, visual gluttony of those same need-less menwhose sense of hearing is tickled by our modern, empty music-

5. manufactureto that idiotic joy which is as repugnant a reward of his performance to the*artist* as it fully answers the intention of the *artisan.* Between the "charmingprospect" and the "pretty tune" of our modern times there subsists a dole-ful affinity, whose bond of unión ¡s certainly not the musing calm ofThought, but that vulgar slipshod *sentimentality* which draws back in selfishhorror from the sight of human suffering ¡n its surroundings, to hire for it-self a prívate heavenlet in the blue mists of IMature's generality.These sen-timentals are willing enough to see and hear everything: only not the *actual,undistorted Man,* who lifts his warning finger on the threshold of their dreams.*Butthisisthe very man whom we must setupintheforefrontof our show!—R.* wagner.

i. It is a little difficult to quite unravel this part of the metaphor, for the same word "Bode/?" is used twice over. I have thought it best to transíate it in the first place as "loam," and in the second as "ground"; for it appears as though the idea were, ¡n the former case, that of what agriculturists cali a "top-dressing," and thus a substance which could break up the lower soil and make ¡tfruitful.The "it" which occurs after the colon may refereither to the "feeling" or to the "orchestra," for both are neuter nouns. —tr. 4. The modern *Playwright* will feel little tempted to concede that Drama oug-: notto belong exclusively to Wsbranch of art,the art of Poesy;above all will he not be able to constrain himself to share ¡t with the Tone-poet,—to w!t, as he understands us; allow the Play to be swailowed up by the Opera. Per-fectly correct! —so long as Opera subsists, the Play must also stand, and, for the matter of that, the Pantomime too; so long as any dispute hereon is thinkable, the Drama of the Future must itself remain un-thinkable. If, however, the Poet's doubt lie deeper, and consist ¡n this, that he cannot con-ceive how *Song* should be entitled to usurp entirely the place of spoken di-: alogue: then he must take for rejoinder, that ¡n two several regards he has not as yet a clear idea of the character of the Art-work of the Future. Firstly, he does not reflect that Music has to occupy a very different posi-tion ¡n this Art-work to what she takes in modern Opera: that only wherei her power is the *fitíest,* has she to open out her ful I expanse; while, on the contrary, wherever another power, for ¡nstance that of dramatic Speech, ¡s the most *necessary,* she has to subordínate herself to that; still, that Music possesses the peculiar faculty of, without entirely keeping silence, so im-perceptibly linking herself to the thought-full element of Speech that she lets the latter seem to walk abroad alone, the while she still supports ¡t. Should the poet acknowledge this, then he has to recognise ¡n the secor j place, that thoughts and situations to which the lightest and most re-strained accompaniment of Music should seem importúnate and burden-some, can only be such as are borrowed from the spirit of our modern Play; which, from beginning to end, will find no inch of breathing-space within the Art-work of the Future.The Man who will portray himself in the Drama of the Future has done for ever with all the prosaic hurly-burly of fashionable manners or polite intrigue, which our modern "poets" have to tangle and to disentangle in their plays, with greatest circumstantiality. His nature-bidden action and hisspeech are:Yea, yea! and Nay, nay!—and all beyond ¡s evil, *Le.,* modern and superfluous. — R. wagner.

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39. In oral cultures, of course, the text had quite a different status in the mind,one that was closer in some respects to the hypertextual model. See Wal-ter J. Ong, *Oralityand Literacy: The Technologizing ofthe Word,* London: Methuen,1982.

40. Lyrical poems are a special case: they are independent works, but have acióse intertextual relationship with others in the same tradition, or by thesame author.

41. We may here distinguish between hypertext and a related concept, Standard Generalized Mark-up Language (SGML). SGML concerns the mark-ing out of units in an electronic text and then attaching to them a "tag" ordescriptive category (such as "noun phrase" or "animal image"). A program can then sort the tags to support grammatical or stylistic analysi; SGML thus sorts textual units by categories; hypertext links the units int larger structures.

66. Nicole Yankelovich, Norman Meyrowitz, and Andries van Dam, "Readinand Writing the Electronic Book," in Landow and Delany; op. cit.

67. For some speculations on these textual megastructures or "docuverses,seethediscussion of the "New Alexandria" in the original, unedited versio of thisessay in Landow and Delaney, op.cit., and Yankelovich, "From Electronic Books to Electronic Libraries," in Landow and Delaney, op. cit.

42. A notable proto-hypertextual work is Humphrey Jennings, *PandemóniumThe Corning ofthe Machine as Seen by Contemporary Observers, 1660-1886,* New YorkFree Press, 1985.This ¡s a chronological series of short passages and ¡mages on the Industrial Revolution; Jennings's posthumous editor, CharleMadge, usted sixteen "Theme Sequences," each of them an altérnate ordering of groups of passages. Jennings's remarkable work could very easily and usefully be adapted for hypertext presentation.
43. Examples of educational hypertext ¡nclude Ben Schneiderman's HypertieHolocaust materials, the many sets of HyperCard materials, including trn Harvard Perseus Project (see Gregory Crane and Elli Mylonas, "AndenMaterials, Modern Media: Shaping the Study of Classics with Hypertext/in Landow and Delany, op. cit.), and the Intermedia materials developed aBrown. Among the applications of hypertext to poetry and fiction one caínumber Michael Joyce's, "Afternoon," Stuart Moulthrop's adaptation oBorges's "Forking Paths"to both HyperCard and StorySpace (see StuarMoulthrop, "Reading from the Map: Metonymy and Metaphor in the Fietion of ᵛForking Paths,' " in Landow and Delany, op. cit.), and WillianDickey's mixed media poetry in HyperCard (seeWilliam Dickey,ᵘPoem Descending a Staircase: Hypertext and the Simultaneity of Experience," iiLandow and Delany, op. cit.).
44. Kenneth Morrell,"Teaching with *HyperCard.* An Evaluation ofthe ComputerBased Section in Literature and Arts C-14:The Concept ofthe Hero in Hel-lenic Civilization." Perseus Project Working Paper 3. Cambridge, Mass.Department of Classics, Harvard University, 1988.

45. Marshall McLuhan, *The Gutenberg Galaxy: The Making of Typographic Man,* Toronto: University of Toronto Press, 1962; Elizabeth L. Eisenstein, *Tht Prínting Press as an Agent of Change: Communications and Cultural Transformations ii Early-Modern Europe, 2* vols. Cambridge, Mass.: Cambridge University Press,1979; and J. David Bolter, *Writing Space: The Computer, Hypertext and the Histor]*

ofWríting Hillsdale, N.J.: Lawrence Erlbaum, 1990.We would Nketothank Professor Bolter for sharing a draft of his work with us before publication.

lorton Heilig, "The Cinema oFthe Future"

68. The nude eye actually has a vertical range of 180°, but this ¡s reduced toapproximately 150° by the brow and cheek of the head.
69. Vistavision, by photographing first on a negative frame twice the originalsize before printing on to normal size positive, has partially returned screenimage to its usual sharpness.

Sutheriand, **"The Ultímate Display"**

46. K.C. Knowlton."A Computer Technique for Producing Animated Movies,"*Proceedings ofthe SpringJoint Computer Conference* Washington, D.C.: Spartan,1964.
47. I. E. Sutheriand. "Sketchpad—A Man-Machine Graphical Communica-tion System," *Proceedings of the SpríngJoínt Computer Conference.* Detroit, Mich. May 1963 Washington, D.C.: Spartan, 1964.

cott Fisher, "Virtual Interface Environments"

ates

23. The principal projectteam at NASA ¡s C. Coler, S. Fisher, M. McGreevy, W.Robinett,and E.Wenzel. At Sterling Software: S. Bryson,J. Humphries, R.Jacoby, D. Kaiser, D. Kerr, and P. Stone.
24. The principal project team at VPL was T. Zimmerman, C. Blanchard, S.Bryson, and J. Grimaud.

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¡arcos Novak, "Liquid Architectures **in Cyberspace"**

otes

5. Bruce Sterling has recently collected five: Gibsonian cyberspace, Barlov-¡an cyberspace, Virtual Reality, Simulation, andTelepresence.The definitionabove is a concatenation of all five plus a sixth, set forth in "Making Reality a Cyberspace" by Wendy Kellog and others.

6. Thomas Kuhn discussed the notion of world lines with respect to scientificconcepts in atalk on

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Char Davies, "Changing Space: Virtual Reality as an Arena oí Embodied Being"

This paper was presented in abridged form at Consciousness Reframed, Ist C Research Conference, Centre for Advanced Inquiry ¡n the Interactive Arts, .

i/ersity of Wales College, Newport,Wales, July 1997, and at Beyond ShelterThe Future of Architecture,The Graham Foundation, Chicago, III., September 1997. It is partially based on the presentations "Soul ¡n the Machine: Osmose—The Paradox of Being in Immersive Virtual Space" and "Osmose as Metaphor: Alternative Aesthetics and Interaction in Immersive Virtual Space," delivered at the annual meeting of the Association for Computing Machinery (ACM) Special Interest Group in Graphics, New Orleans, La., August 1996.
Osmose was designed as an alternative to the dominant aesthetic and inter-active sensibility of virtual reality. The work was created by myself, JohnHarrison, and Georges Mauro, with sound by Ríck Bidlack and DorotaBlaszczak, and was produced by Softimage between 1994 and 1995. Public installations of the work were made in an intímate enclosed immersionárea with a darkened visitor space. Visitors were able to "witness" each ¡m-mersive journey from the immersant's point of view as it took place via liveaudiovisual connection. Adjacent to the video projection was a live shadowprojection of the ¡mmersant, providing an associative link between his orher body as conduit for lived experience, and the work's consequent ¡m-agery and sound. For a more detailed description, see "Osmose: Notes onBeing in Immersive Virtual Space," paper delivered at the 6th International Symposium on Electronic Art, Montreal, September 1995, and CharDavies and John Harrison, "Osmose—Towards Broadening the Aesthetics of Virtual Reality," in *ACM Computer Graphics,* vol. 30, no. 4, November 1996,

73. pp. 25-8.
74. The subjective experience of being spatially enveloped or immersed in avirtual environment is key

to my work and the views expressed ¡n thispaper. By "¡mmersion" or "¡mmersive virtual space" I specifically meanimmersion within a spherically 360-degree, totally enveloping virtualspace, implying a "being within." In my experience with VR, such sensa-tion of envelopment is possíble only through the wearing of a head-mounted display helmet with a wide field of view. While the word "¡mmersive" is currently being used by the industry to describe wrap-around screens and domes (creating what I consider to be nonimmersive experiences) my use of the word "¡mmersive" denotes a *totally* envelopingvirtual space.

75. Gastón Bachelard, *The Poeticsof Space* (Boston, Mass.: Beacon Press, 1966,p. 206. For Bachelard's discussion on the psychologically transforming qualities of immense open spaces such as the sea, desert, and plains, see pp.203-10.

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48. Arthur Deikman, "Deautomatization and Mystical Experience" and "Experimental Meditation," ¡n *Altered States of Consciousness,* Charles Tart, ed.,New York: HarperCollins, 1990, pp. 50, 262-3. Note that ¡n terms of "re-ceptivity" to Osmose, I have been told by at least one individual that al-though she was intellectually skeptical when she went ¡n, "something happened" and much to her surprise she became entranced.This points tothe medium's potency, for better and worse.
49. Deikman, "Deautomatization," p. 52.
50. Ibid., pp. 47-55.

51. Y. Karim, personal correspondence with the author, September 1995. *"Osmose* heíghtened an awareness of my body as a site of consciousness and ofthe experience and sensation of consciousness occupying space."

52. This method was partially informed by my own practice of scuba diving ¡rthe deep sea, certainly a "psychically innovating space" as Bachelard suggested. Diving at depths of 200 feet over a 6,000-foot abyss introduced meto the experience of being within an almost puré, abstract yet sensuous'..enveloping space, where when there is nothing to "look at" perceptual andcognitive distinctions between near and far, inside and out, really do dis-solve. While diving, navigation and buoyancy are achieved through subtle and skillful use of breath and balance, and the use of hands is discouraged.There are other relevant comparisons between diving and immersive virtual environments, such as the donning of heavy gear in order to access suc"spaces, as well as the necessity of limiting the length of the experience inorder to avoid possible dangers to one's health.

Verana Conley, preface to *V* (1993), in *Rethínking Technologies,* Verana Conley, ed., Minneapolis: University of Minnesota Press, 1993, p. ix.

76. Ibid., p. xii.

In its most prevalent form, immersive virtual reality can be considered tobe "a literal re-enactment of Cartesian ontology." Richard Coyne, "Hei-degger & Virtual Reality: The Implications of Heidegger's Thinking forComputer Representaron," *Leonardo,* vol. 27, no. 1, 1994, pp. 66-75. Interms of visuals, most real-time three-dimensional computer graphic tech-niques are based on representing "hard-edged solid objects in empt..space" —in a combination of low-level mimetic realism, Cartesian space,and Renaissance perspective. In virtual environments the human subject isusually reconstructed as an omnipotent and isolated viewpoint maneuver-ing in empty space and probing objects with an acquisitive hand. Interactivity in many commercial computer games involves adrenaline-producing high-speed action and aggression. These approaches tend to reinforce a Cartesian way of seeing the world in terms of emphasizing the separation of subject over object, mind over body, and the world as "standing-reserve." For a discussion about the world being reduced to "standing-reserve" for human consumption, see Martin Heidegger, "The Question Concerning Technology," in *The Question Concerning Technology & Other Essays, New* York: Harper & Row, 1977, pp. 17-27. The imperative to master and control is not sur-prising given the technology's origins, not only in value-wise in the Western philosophic tradition, but instrumentally in the military as well.

II Viola, "Will There Be Condominiums in Data Space?"

'.. A. R. Luria, *The Mind of the Mnemonist,* New York: Basic Books, 1968.

!. The Greeks perfected a system of memory that used the mental im-printing of any objects or key points to be remembered onto specific lo-cations along a pathway previously memorized from an actual temple. To recall the points in their proper order, one simply had to take the walk through the temple in one's mind, observing the contents left at each lo-cation along the way.

. A. K. Coomaraswamy, *The Transformaron of Nature in Art,* NewYok: Dover Pub-lications, 1956; reprint of the original Harvard University Press edition, Boston, 1934.

A Landmark Interactive laserdisc project by MIT Media Lab, in the late 1970s, that mapped the city of Aspen, street by street, with moving cameras so that the viewer could take a "ride" through the city, going anywhere at will —one of the first visual-mapping datábase moving-image projects related to data space ideas and today's virtual reality technology.

Ascott, "Is There Love in the Telematic Embrace?"

The neologism "telematique" was coined by Simón Nora and Alain Mine in *L'Informatisation de la societe,* París: La Documentation Francaise, 1978. The Germán word *"Gesamtkunstwerk"* was used by Richard Wagnerto refer to his visión of a "total artwork" íntegrating music, image, and poetry.

77. Humberto R. Maturana and Francisco J. Várela, *The TreeofKnowledge: Thelological Roots of Human Understanding,* Boston: Shambhala, 1987.
78. Roland Barthes, "From Work to Text," ¡n *Image-Music-Text,* trans. StepNHeath, New York: Hill &Wang, 1977.
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83. See Michel Sanouillet, ed., *Salt Seller: The Writings of Marcel Duchamp* (Manhand du Sel) New York: Oxford University Press, 1973.

53. Charles Fourier (1772-1837). His "system of passionate attraction (elaborated ¡n *Theoriedesquatresmouvementset des destinees generales* C París: Bireaux de la Phalange, 1841]) sought universal harmony.
25. Peter Russell, *The Awakening Earth,* London: Routledge, 1982.

27. James L. McClelland, David E. Rummelhart, and the PDP ResearcGroup, *Parallel Distributed Processing,* vol. 1, Cambridge, Mass.: MIT Pres¡ 1986.
28. The term was first proposed in Roy Ascott, "Art and Telematics: Towarda Network Consciousness," in *Art Telecommunications.* Heidi Grundmann, ed Vancouver: Western Front, 1984.
18. Paul J. Curran, *Principies of Remote Sensing,* New York: Longman, 1985.
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9. Roy Ascott, "Art,Technology and Computer Science," in XLII EsposizionInternazionale d'Arte (Venice: Biennale di Venezia, 1986). The international commissioners for the 1986 Biennale were Roy Ascott, Don ForestéTom Sherman, and Tomaso Trini.
10. Roy Ascott, "Gesamtdatenwerk: Konnektivitat, Transformation and Trar]szendenz," in *KunstforumIQ3* September/October 1989. Project by Roy Ascott in collaboration with Peter Appleton, Mathias Fuchs, RoberPepperell, and Miles Visman.
11. Norbert Wiener, *Cybernetícs or Control and Communicatíon in the Animal and Machín*Cambridge, Mass.: MIT Press, 1948.

20. VPL Research, Incv of California demonstrated "shared virtual reality" and"walk-through cyberspace"atTexpo '89 ¡n San Francisco, June 1989.

'avel Curtís, "Mudding: Social Phenomena in Text-Based **'irtual Realities"**

84. Forster, E. M., "The Machine Stops," in *The Science Fíction Hall of Fame,* vol.IIB, Ben Bova, ed., Avon, 1973. Originally ¡n E. M. Forster, *The Eterna! Mo-ment and Other Stories,* New York: Harcourt Brace Jovanovich, 1928.
85. Eric S. Raymond, ed., *The New Hacker's Dictíonary,* Cambridge, Mass.: MITPress, 1991.
86. In fact, these two commands are so frequently used that single-characterabbreviations are provided for them.The two example commands wouldusually be typed as follows:

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Can anyone
hear me?
:smiles.
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4. Forster, op cit.
5. The "MOO" in "LambdaMOO" stands for "MUD, Object-Oriented." The origin of the "Lambda" part is more obscure, based on my years of experience with the Lisp programming language. b. Van Gelder, Lindsy, "The Strange Case of the Electronic Lover," in Dunlop

and Kling, op. cit. *7.* Sara Kiesler et al., "Social Psychological Aspects of Computer-Mediated Communication," in *Computerízatíon and Controversy,* Charles Dunlop and Robert Kling, eds., San Diego, Calif.: Academic Press, 1991. Kiesler and her colleagues nave investigated the effects of electronic anonymity on the decision-making and problem-solving processes in organizations; some of their observations parallel mine given here. '. Van Gelder, op cit. . Morningstar, Chip, and F. Randall Farmer, "The Lessons of Lucasfilm's Habitat," in *Cyberspace,* Michael Benedikt, ed., Cambridge, Mass.: MIT Press, 1991.

. Forster, op cit.

54. McLuhan, Marshall, *Understanding Medía,* New York: McGraw-Hill, 19i

55. Forster, op cit.

Fierre Lévy, "The Art and Architecture oF Cyberspace"

1. William Gibson, *Neummancer,* New York: Ace Science Fiction Books,]

Janet Murray, "Agency"

26. Gilíes Deleuze and Félix Guattari, *A Thousand Plateaus: Capítalism and ;phreriía,* Minneapolis: University of Minnesota Press, 1987.
27. Stuart Moulthrop,"Containing Multitudes:The Problem of Closureteractive Fiction," *Association for Computen and Humanities Newsíetter,* vo1988, p. 1.
28. The authoring environment Storyspace, distributed by Eastgate Syswas designed by Jay David Bolter, John Smith, and Michael Joyce.the virtue of allowing the writer to see a text as a series of lexias dispas boxes with links between them in the form of arrows. Storyspace pan ¡mportant role ¡n popularizing hypertext writing in academic circlfore the arrival of the World Wide Web.
29. The robbery story is "Flow" by Robert Frederick.
30. David Thorburn, "Televisión Melodrama," ¡n *Televisión: The Critical Vie\race* Newcomb, ed., Oxford, England: Oxford University Press, pp. 53
31. I am grateful to Matthew Gray for telling me about this puzzle in Z
32. Of course, as the reader response critics (see Norman N. Holland,*namics of Literary Response,* Oxford, England: Oxford University Press,Norman N. Holland, *5 Readers Reading,* New Haven, Conn.: Yale Un¡\Press, 1991; Wolfgang I ser, *The Act of Reading: A Theory of Aesthetic Re*Baltimore, Md.: Johns Hopkins University Press, 1978; Umberto Ei *Role of the Reader,* Bloomington: Indiana University Press, 1979) remireading and viewing are not passive experiences at al I but require us tstruct the story ¡n an active manner.There is still a difference, howev tween this emotional and cognitive activity and the external actions v\¡n a game or electronic narrative. Perhaps the most ¡mportant diffi¡s that ¡n the latter we are conscious of our activity, which changes c lation to the story.

29. For more on the interpretaron of games, in a more anthropological ratherthan literary context, see Elliot M. Avedon and Brian Sutton-Smith, *TheStudy of Games,* Huntington, N.Y.: R. E. Krieger, 1979.

30. Tetris (Spectrum Holobyte, 1987) was originally designed by AlexeyPazhitnov in Moscow in 1985.Thanks to Elizabeth Murray and HenryJenkins for sharing their Tetris experiences with me.

.0. For a consideration of the agón as a characteristic organizing form of oral culture, see Walter J. Ong, *Oralityand üteracy: The Technologizing ofthe Word,* New York: Methuen, 1982, pp. 43-45.

a note on the web site

artmuseum.net http://www.artmuseum.net/w2vr

Multimedia: From Wagnerto Virtual Reality \s a unique hybrid pu:-lishing project that joins W.W. Norton & Company with o_-media partner, Intel Corporation's ArtMuseum.net, to pre-sent an untold history of multimedia.

The book and the Web site are meant to work in ta."-dem. On-line, *Multimedia: From Wagnerto Virtual Reality* is a :.--namic, growing resource featuring hyperlinked texts **ana** wealth of multimedia documentaron—vintage photogra:": rare video clips, and an Interactive timeline chronicling r medium's pioneers. It also includes "in-depth" profiles d several of the artists and scientists featured in the book ^ -tending its scope to include ¡llustrated descriptions of t artworks and technological invention that underlie the *-. :* lution of the médium.

The site was developed ¡n cióse collaboration with A Museum.net and Intel's Arts and Education program. *'.:* our hope that the Web site will serve as a valuable res: for students, teachers, artists, and critics probing the active media arts, as well as those attempting to make s=-:-of this burgeoning médium that is transforming our *í* our culture.

Acknowledgment

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